Gibbons

Volume 64 | June, 1950 | $4.00 a Year
Number 2 | Page 91-193 | $1.25 a Number

Journal of the New England Water Works Association

ISSUED QUARTERLY

Published by
THE NEW ENGLAND WATER WORKS ASSOCIATION
73 Tremont Street, Boston 8, Massachusetts

Entered as second-class matter September 23, 1905, at the Post Office at Boston, Mass., under Act of Congress of March 3, 1879
Copyright, 1950, by the New England Water Works Association

OFFICERS
OF THE
New England Water Works Association
1949 - 1950

PRESIDENT

SIDNEY S. ANTHONY, Superintendent, Augusta Water District, Augusta, Maine.
(Term expires September 1950)

VICE PRESIDENTS

THOMAS R. CAMP, Consulting Engineer, Camp, Dresser & McKee, Boston, Mass.
(Term expires September 1950)

FREDERICK O. A. ALMQUIST, Principal Sanitary Engineer, Connecticut State Department of Health, Hartford, Connecticut.
(Term expires September 1951)

DIRECTORS

STANLEY M. DORE, Deputy Chief Engineer, Construction Division of the Metropolitan District Commission, Boston, Massachusetts.
(Term expires September 1950)

WILLIAM B. DUFFY, Superintendent, Public Works, North Andover, Massachusetts.
(Term expires September 1951)

ROGER G. OAKMAN, Superintendent, Water Division, Needham, Massachusetts.
(Term expires September 1952)

PAST PRESIDENTS

DONALD C. CALDERWOOD, Superintendent and Engineer, Pennichuck Water Works, Nashua, New Hampshire.

ARTHUR C. KING, Superintendent, Taunton Water Works, Taunton, Massachusetts.

SECRETARY

JOSEPH C. KNOX, Secretary, New England Interstate Water Pollution Control Commission, Boston, Massachusetts.

TREASURER

WILLIAM P. MELLEY, Commissioner, Milton Water Department, Milton, Massachusetts.

EDITOR

GEORGE C. HOUSER, 220 Clyde Street, Brookline 67, Massachusetts.

THE Association was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 900 men. Its membership is divided into six classes, viz.:

A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Junior shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation.

The initiation fees and annual dues are as follows:

Initiation Fees		*Annual Dues*	
Members	$ 5.00	Members	$ 5.00
Juniors	1.00	Juniors	1.00
Associates	10.00	Associates	25.00
Corporate Members	10.00	Corporate Members	10.00

This Association has at least eight regular meetings each year, of which five are held in Boston, one in northern New England, one in southern New England, and one, the annual convention, held in September on such date as the Executive Committee may designate.

From mammoth to midget...
according to your requirements
120" Lock Joint Reinforced Concrete Pressure Pipe and 16" Lock Joint Prestressed Concrete Cylinder Pipe

Whether your daily water consumption demands be 3,000,000 gallons or hundreds of times that figure, Lock Joint Pipe Company is prepared to provide the supply line you need.

In the last few years the Company has supplied not only hundreds of miles of large diameter pipe but also more than a million feet of 16" to 24" pipe for municipalities and industry. This has been made possible through the establishment of three permanent manufacturing plants. Lock Joint Concrete Pressure Pipe from 16" to 42" in diameter, produced at these plants, can be shipped economically to all parts of the country for major installations and minor extensions.

Our representative will be glad to discuss with you any water supply or transmission project which calls for pressure pipe 16" in diameter or larger. You will find that Lock Joint Concrete Pressure Pipe's superior characteristics of long life, continuous high flow and negligible upkeep will recommend it above all others for any permanent installation.

LOCK JOINT PIPE COMPANY

Est. 1905

P.O. Box 269, East Orange, N. J.

Pressure Pipe Plants:
Wharton, N. J. • Turner, Kan. • Detroit, Mich.

BRANCH OFFICES: Casper, Wyo. • Cheyenne, Wyo. • Denver, Col. • Kansas City, Mo. • Valley Park, Mo. • Chicago, Ill. Rock Island, Ill. • Wichita, Kan. • Kenilworth, N. J. • Hartford, Conn. • Tucumcari, N. Mex. • Oklahoma City, Okla. • Tulsa, Okla.

SCOPE OF SERVICES—Lock Joint Pipe Company specializes in the manufacture and installation of Reinforced Concrete Pressure Pipe for Water Supply and Distribution Mains in a wide range of diameters as well as Concrete Pipe of all types for Sanitary Sewers, Storm Drains, Culverts and Subaqueous Lines.

Another **ROCKWELL CONTRIBUTION**

TO BETTER METER PERFORMANCE

PITTSBURGH EQUITABLE

Water Meters

Precisely TESTED UNDER ACTUAL OPERATING CONDITIONS

***This* ELECTRONICALLY CONTROLLED TESTING PLANT** in our water meter factory is the only one of its kind. It will handle up to 240 meters at a time on four test lines. In it, your orders for any of the domestic sizes of Pittsburgh Equitable meters (Arctic, Tropic or Empire) will be precisely tested for accuracy to your specifications. The control panels can be quickly adjusted to match the conditions that will be actually found in your system. For example, where specified, meters going into warm climates can be tested for accuracy and response at water temperatures of 100° F. or higher.

By duplicating your actual operating conditions on the test stand we assure accurate measurement from the word "go". Now, more than ever before, good basic designs, plus careful workmanship and exacting tests make your choice of any Pittsburgh Equitable meter an outstanding value.

YOUR UNRESTRICTED *Choice* OF METER TYPES

Empire Type 12

Empire Type 14

Arctic

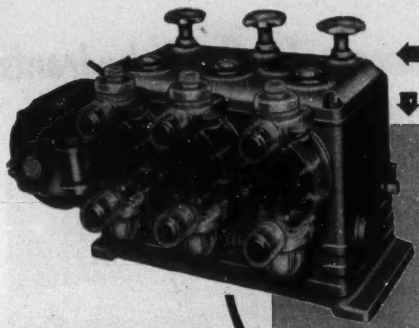
Tropic

Pittsburgh Equitable Meter Division

ROCKWELL MANUFACTURING COMPANY

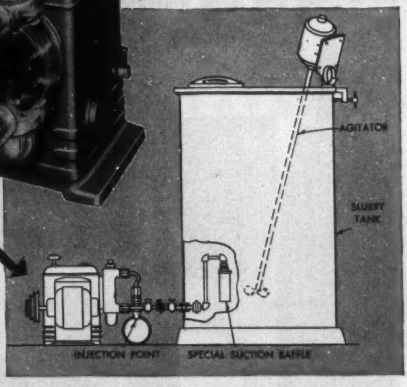
Pittsburgh 8, Pa.

Atlanta Boston Chicago Columbus Houston Kansas City Los Angeles New York Pittsburgh San Francisco Seattle Tulsa



Triplex Heavy Duty Chem-O-Feeder

Typical Slurry Feeding Installation



OK For FEEDING SLURRIES *Against Pressure!*

- **LIME SLURRY FOR pH CORRECTION**
- **ACTIVATED CARBON SLURRY FOR TASTE AND ODOR CONTROL**
- **DIATOMACEOUS EARTH SLURRY FOR FILTRATION**
- **CALCIUM CARBONATE SLURRY FOR WATER CONDITIONING**

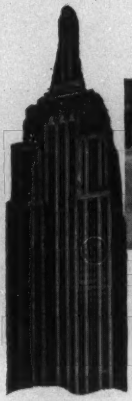
% Proportioneers % new Heavy Duty Chem-O-Feeder solves a difficult feeding problem — it's ideal for feeding abrasive slurries against pressure — positively, accurately — without wearing out pump parts. For handling slurries the Chem-O-Feeder has semi-knife edge check valves of stainless steel or silver, with a diaphragm of whipcord-reinforced soft rubber.

The feeding rate can be adjusted with extreme accuracy by merely turning a knob, without stopping the Chem-O-Feeder. A magnifying register glass shows exact reading of stroke length in increments of .001". The plastic See-Thru reagent heads, convenient oil fill, and automatic lubrication reduce maintenance to a minimum. Chem-O-Feeders are available in Simplex, Duplex and Triplex Models to feed up to 8 g.p.h. per unit at pressures to 125 psi. Can be furnished with one or more slurry feeding heads, with other heads feeding different water treating chemicals. Write for information.

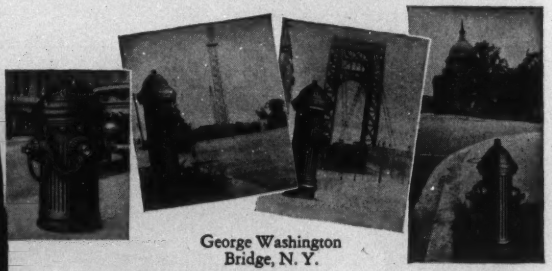
% PROPORTIONEERS, INC. %

366 HARRIS AVE. PROVIDENCE 1, R. I.

Many are the reasons why Smith hydrants are used by America's leading cities!



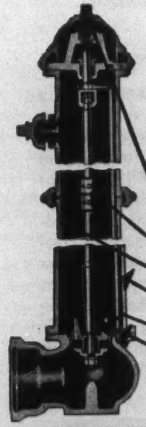
Empire State Bldg., N. Y.



George Washington Bridge, N. Y.

Capitol Building, Wash., D. C.

Independence Hall, Phila.

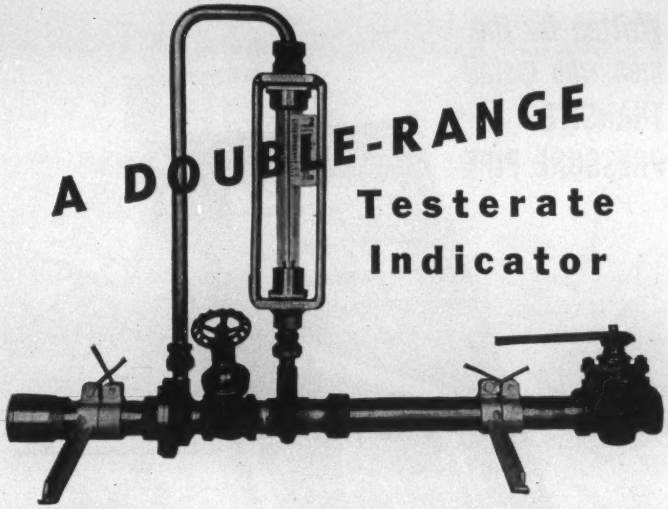


New York — Philadelphia — Washington — Baltimore — St. Louis — Providence and scores of other cities throughout the nation use SMITH hydrants — and not without good reason. A few of these reasons can easily be seen upon inspection of the hydrant section shown at the left.

1. Working parts easily removed from top.
2. Frangible couplings for collision protection.
3. Maximum flow due to large stand pipe areas.
4. Tapered, frost-proof barrel
5. Compression-type valve.
6. Positive action drain—always closed when main valve is open.

THE A. P. SMITH MFG. CO.
ESTABLISHED 1874
EAST ORANGE, NEW JERSEY

A DOUBLE-RANGE Testerate Indicator



. . . you can take out on the job

WRITE FOR CATALOG 50

It contains full information about the Double Range Indicator and other valuable meter testing and setting equipment. FREE.

With this Portable Double Range Testerate Indicator you can field test meters at rates of flow anywhere between 1/4 g.p.m. and 175 g.p.m. Accuracy is within 2%. The value of the time saved is considerable. Each Indicator is equipped with lubricated plug valve, spring-loaded check valve and four adjustable supporting legs.

The TESTERATE INDICATOR

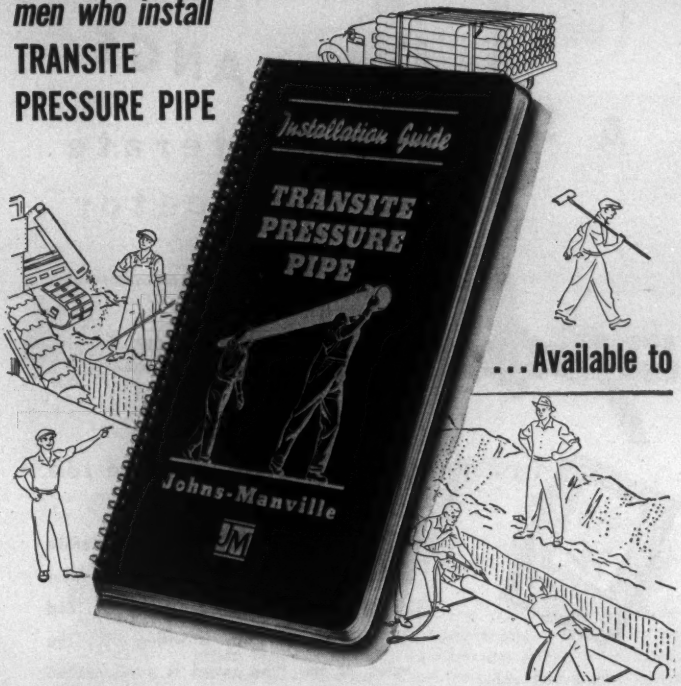
FOR BETTER WATER SERVICES

FORD

Manufactured by THE FORD METER BOX COMPANY, INC.

Wabash, Indiana

Written for the men who install TRANSITE PRESSURE PIPE



. . . Available to

As its title implies, this new Installation Guide was designed especially for those who do the actual work of installing Transite* Pressure Pipe . . . a handy working tool intended to help the man in the field do a good job in an economical way.

But it answers so many questions of general interest about Transite Pipe that it is being offered, without cost, to anyone concerned with the design, construction or operation of a water system.

Send for your copy today. It will give you a new insight into Transite's many practical features that reduce water line installation costs . . . help answer some of the questions you may have about this Johns-Manville asbestos-cement pipe that is contributing to better and more economical water systems for thousands of American cities and towns.

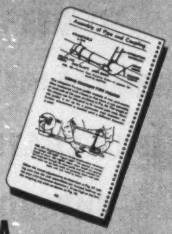
*Transite is a registered Johns-Manville trade mark

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville TRANSITE

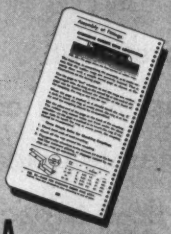
FOR BETTER

Q. How is Transite Pipe assembled in the trench?



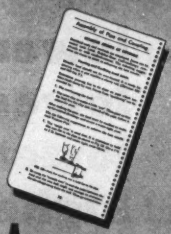
A. By means of the Simplex Coupling, a factory-made joint. See page 38.

Q. How are joints checked for correct assembly in advance of leakage tests?



A. By the use of a simple feeler gage as described on page 50.

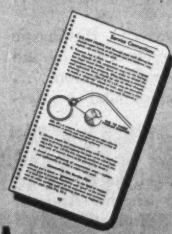
Q. Are standard practices used for making joints at fittings?



A. Yes—see "Making Joints at Fittings" page 78.

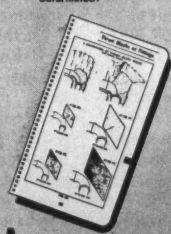
anyone who wants the answers to questions like these

Q. Can you cut, machine and tap Transite Pipe in the field?



A. Yes—see "Cutting Transite Pipe" page 72 and "Service Connections" page 91.

Q. How are size and type of thrust blocks at fittings determined?



A. The Guide gives helpful data, including tables, construction, and location. See page 82.

Q. What about trench preparation, supporting the pipe, and tamping?

A. Standard methods are employed. See pages 16, 23 and 97

Just use the coupon—or write to Johns-Manville, Box 290, New York 16, N. Y. In Canada, address 199 Bay Street, Toronto, Ontario.

ASBESTOS-CEMENT **PRESSURE PIPE**

WATER SERVICE

Johns-Manville
Box 290, New York 16, N. Y.

Please send me the Transite Installation Guide (TR-62A).

Name_____

Organization_____

Address_____

City_____ State_____

(Key No.)

IN LARGE-DIAMETER WATER LINES . . .

for **lower** first cost
lower operating cost
lower maintenance cost
and **higher** flow capacity

STEEL WATER PIPE---LINED AND COATED WITH KOPPERS BITUMASTIC 70-B ENAMEL

STEEL water pipe lines, protected inside and out by a durable coating of Koppers Bitumastic® 70-B Enamel, offer you greater savings from every angle than other types of large-diameter water line installations.

Inside the pipe, the spun lining of Koppers Bitumastic 70-B Enamel prevents tuberculation and rust. It's unnecessary to compensate for possible corrosion losses by specifying oversized diameters or additional wall thickness. The glass-smooth lining maintains a high coefficient of flow both initially and after decades of service. The resulting reduction in pumping costs is substantial.

On the pipe exterior, Bitumastic 70-B Enamel prevents pitting and leakage due to soil corrosion . . . keeps maintenance and replacement costs low.

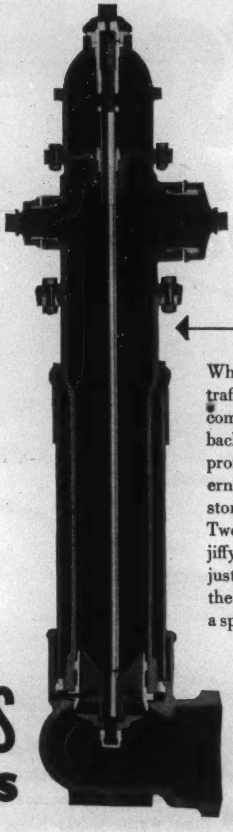
Steel pipe itself offers you other important savings. Fewer joints are required, since steel pipe can be furnished in longer lengths. And the purchase price of Bitumastic-coated steel pipe is low, too.

Give your community the most for its tax dollars by specifying steel water pipe lined and coated with Koppers Bitumastic 70-B Enamel.

KOPPERS BITUMASTIC ENAMELS
REG. U.S. PAT. OFF.

KOPPERS COMPANY, INC., Tar Products Division, Dept. 606T, Pittsburgh 19, Pa.

SPEED OF REPLACEMENT MEANS SAFETY FOR THE COMMUNITY



When a hydrant is broken in a traffic accident, it is a matter of community concern to get it back in operating condition promptly. The Mathews Modernized Hydrant can be restored in a matter of minutes! Two men can do the job, in a jiffy and *without excavating*, just as soon as they can get to the scene of the accident with a spare barrel and a lug wrench.

MATHEWS HYDRANTS

Made by R. D. Wood Company

Public Ledger Building, Independence Square

Philadelphia 5, Pa.

Manufacturers of "Sand-Spun" Pipe (centrifugally cast in sand molds) and R. D. Wood Gate Valves.

THE FIREMAN'S FRIEND

Mathews Modernized Hydrants Set the Pace: Easily maintained because simple in construction • All working parts contained in the replaceable barrel • Stuffing box cast integral with nozzle section • Head can be turned 360° • Replaceable head • Nozzle sections easily changed • Nozzle levels raised or lowered without excavating • Protection case of "Sand-Spun" cast iron for extra strength, toughness, elasticity • Operating thread only part to be lubricated • A modern barrel makes an old Mathews good as new

YES...

IT'S MEANT FOR YOU!!

This new MUELLER Blue Top Catalog is meant to provide engineers and water works men with a simple, accurate means of selecting their water works brass goods requirements. It illustrates the complete Blue Top Line and gives full dimensional data on each item. You'll find it invaluable for constant reference, so if you haven't a copy handy right now, don't delay — write for one today.

DEPENDABLE SINCE 1857 FULLY WARRANTED
OUR 91st YEAR

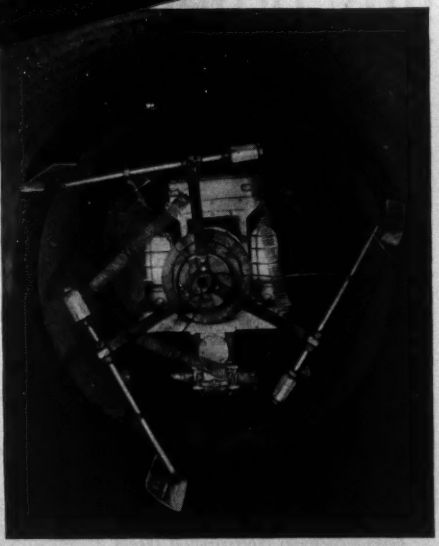
MUELLER CO.

EASTERN SALES OFFICE, 1322 EMPIRE STATE BLDG., N. Y. C., N. Y.
MAIN OFFICE AND FACTORY DECATUR, ILLINOIS
OTHER FACTORIES: Los Angeles, Cal., Chattanooga, Tenn., Sarnia, Ont., Canada

CENTRILINE

CONFORMS STRICTLY WITH A.W.W.A. SPECIFICATIONS

▶▶▶ PIPE LINING FACTS NO. 3



▶▶▶▶ The Standard Specifications for cement-mortar protective coatings issued by the American Water Works Association provide: "Interior of the entire line, including both curves and tangents, shall be by centrifugal machine . . . the machine shall apply the mortar by centrifugal action without the use of compressed air and follow its application by automatic trowelling to a uniform thickness and smooth finished surface."

The strict adherence to these specifications by Centriline insures a continuous, dense, smooth lining—applied without rebound—that means restored carrying capacity perpetually sustained and longer life to mains. If pipelines are losing efficiency it is time to consider Centrilining. Our engineers stand ready to assist you.

▶▶▶▶ WRITE TODAY FOR THE NEW CENTRILINE CATALOG

CENTRILINE CORPORATION

A subsidiary of Raymond Concrete Pile Co.

142 CEDAR STREET - NEW YORK 6, N. Y.

Branch Offices in all Principal Cities in the United States and Latin America

CEMENT MORTAR LININGS FOR WATER MAINS

Centrifugally Applied in Strict Conformity with A.W.W.A. Specifications

"Have not purchased any other than Badger meters since 1924"

This is what the Service Manager of one city's Gas & Water Department wrote to another city:

"These meters have given such excellent service, and the repair cost is so low, that we have not purchased any other type of meter since 1924. It is a pleasure to recommend Badger Meters to you".

In over 5000 communities, waterworks men know that "It pays to BUY BADGER".

Every waterworks superintendent should have the NEW BADGER CHART No. 689 (Practical Plan for Meter Storage Rack.) WRITE today for this chart . . . no charge.

BADGER METER MFG. CO.
Milwaukee 10, Wisconsin

BRANCH OFFICES:
New York City • Philadelphia • Worcester, Mass. • Savannah, Ga. • Cincinnati • Chicago Kansas City, Mo. • Waco, Texas Salt Lake City, Utah • Portland, Ore. • Seattle, Wash. • Los Angeles

You will find a Badger Meter size and type for every waterworks service. Shown here are Model SC-SOT (for warm climates), and Model A-SOT (for cold climates) . . . sizes 5/8" to 1 1/4" . . . other sizes up to 12". Write for complete information and prices.

BADGER Water METERS

ACCURACY · LOW-COST MAINTENANCE · DURABILITY · SENSITIVENESS

Table of Contents

PAGE

How Groton Meets Its Growing Demand for Water
By Lendon F. Dutton 91

A Decade of Operating Experience at the Groton Filter Plant
By A. C. Greenleaf 97

Revitalizing Old Water Systems
By Kenneth H. Holmes 107

Water-Works Operating Expenses under Post-War Conditions
By Frank A. Marston 119
By Percy A. Shaw 125
By Theodore L. Bristol 129
By Edwin T. McDowell 131

Iron and Manganese Removal in the Spaulding Precipitator
By R. H. Babcock 138

Mutual Interests between the Water-Works and Atomic-Energy Industries
By Arthur E. Gorman 148

Observations on Water Samples from Cement-Asbestos Pipe Systems in Vermont
By Edward L. Tracy 164

Improving Water Quality by Cleaning Reservoirs and Draining Swamps
By Marshall S. Wellington 179

Memoirs:
James F. Sanborn 185
George H. Finneran 187
Harry W. Clark 187

Letter Relative to Death of Aubrey Thomas Hobbs 189

Proceedings:
February 1950 Meeting 190
March 1950 Meeting 190

Public Utilities under the Amended Federal Wage-Hour Law 192

New England Water Works Association
ORGANIZED 1882

VOL. LXIV JUNE, 1950 No. 2

This Association, as a body, is not responsible for the statements or opinions of any of its members

HOW GROTON MEETS ITS GROWING DEMAND FOR WATER

BY LENDON F. DUTTON*

[*Read April 21, 1949.*]

ABOUT the turn of the century, agitation developed for a public water supply in the community called "Groton Bank", in the western part of the town of Groton, which is located on the east shore of the Thames River at its mouth. As is often the case in New England communities, where citizens are proud of their freedom of individual thought, differences of opinion delayed the consummation of a plan. Finally in 1902, a group grown tired of waiting formed the Groton Water Co. and built a water works. Once the system was inaugurated, the citizens composed their differences and in 1903 the State Legislature chartered this community "The Borough of Groton", with powers to construct and operate a public water supply, a system for the supply of electricity, a sewerage system and a gas system. In some respects, particularly in recent years, the experiences of the Groton Water Works have been somewhat unique for this part of the country.

Until the late 1930's, the requirements of the community were not unlike those of other similar places in New England. The demand for water grew slowly and eventually reached a comparatively static basis at something less than 1 mgd, except during the first World War, when it increased to between 1.5 and 2 mgd. The activities at the U. S. Navy Submarine Base and at the Electric Boat Co. were largely responsible for this rise, which subsided after the war.

During World War II the water consumption again rose, due to similar activities on a larger scale, together with the establishment of the Coast Guard Training Station at Eastern Point and Trumbull Air Field. This time the demand reached about 3 mgd and has dropped back only to about 2 mgd. It seems certain to rise again in the next year or two to about 4 mgd, when the Charles Pfizer Co., which has

*Superintendent, Department of Utilities, Groton, Conn.

acquired the site and buildings of one of the war plants, gets into full production. This company requires large quantities of high-quality water in the manufacture of pharmaceuticals and antibiotics.

As it is anticipated that the present activity may be the beginning of an industrial era in this locality, with its tidewater facilities and ample plant sites, it is forecast that water consumption may soon reach 6 mgd. It is this rise, in about ten years, from less than 1 mgd to a certain 4 mgd and a possible 6 mgd that makes the Groton situation unusual.

The source of supply is Great Brook with a catchment area of about 14 sq mi. A low earth-and-masonry dam just above the village of Poquonnock Bridge provides a reservoir from which water is pumped. Pumping was first done by steam, with supplementary water power developed from the surplus flow of the stream when available. Later an early-type, mechanical-injection Diesel engine was added and finally the pumping station was electrified. The water wheels and the Diesel engine are still connected with a line-shaft, which drives a generator capable of meeting the minimum requirements of the present plant. This generator has been so used on only one occasion, during a protracted power outage caused by a severe storm.

Until 1939 water was pumped directly into the distribution system after chlorination. In that year a rapid-sand filter plant[1] was placed in operation, as a result of a growing demand for water free from color and safeguarded against the increasing hazard of pollution. The decision to construct a filter plant with a nominal capacity of 2 mgd, at a time when consumption was less than 1 mgd and falling, was considered by some to be extravagant, but as events have proven, it was not large enough. Now, after less than ten years, it has become necessary to plan additional facilities for producing a total of 4 mil gal of filtered water daily. Construction has recently started on these additions, which are designed to permit convenient further extension to provide a total nominal capacity of 6 mgd.

The new works consist of a low-lift pumping station on the bank of the Borough reservoir, with initial pumping capacity up to 6 mgd and provision for increasing this to 9 mgd, enabling the operation at 50% overload of 4- and 6-mgd plants, respectively; new settling basins

[1]This JOURNAL, Vol. LV, No. 2, 1941, p. 233.

to bring plant capacity up to 4 mgd; four new 1-mgd filter boxes, only two of which will be equipped at present, and additional high-lift pumping capacity. A steel elevated tank will provide wash water for the new filters, which are twice the size of the existing units and, therefore, cannot economically be served directly by wash-water pumps. The plans provide for the addition of a wing, in which gasoline-engine-driven generators can be installed, to carry the plant through a failure of the normal electrical supply. The ultimate construction of this wing will depend upon the severity of future experience with power outages.

The new low-lift station will serve both old and new filter plants. The new filter plant will function independently of the old and in parallel with it, but the buildings will be interconnected for convenience of operation and economy of staff. The effluent pipes from both plants will be brought together, for final chlorination or other conditioning of the filtered water before pumping into the distribution system.

At the present time, there is not much to see but a cofferdam for the new low-lift pumping station and miscellaneous excavations. However, you can visit the present filter plant, in which we take pride as a compact and well-functioning unit. Its performance will be described in another paper here today. During its ten years of operation it has satisfactorily met the requirements of extended periods of war-time overloads up to 50%.[2]

As a result of the limited storage in the existing Borough reservoir, the dependable yield of our watershed is barely sufficient for requirements which are in sight. For some years we have had in mind the ultimate need of a new reservoir, for which there is a good site partway up the valley of Great Brook. The construction of a dam to create this impounding capacity is a part of the program for systematic development of our 14 sq mi of watershed and will be the next major step. It will be essential, if we are to meet the 6-mgd demand which is foreseen.

During the recent war, the limit of capacity as then developed was reached and emergency steps were taken to augment the yield. Adjacent to the reservoir is Smith Lake, a tributary body of water

[2]This JOURNAL, Vol. LXII, No. 1, 1948, p. 95.

which happens to be much deeper than the reservoir. A vertical deep-well-type pump was installed at the end of a pile trestle, built out into the lake, by means of which the storage available in the lower depths of this lake could be transferred into the nearby shallower reservoir. It has been unnecessary to utilize this expedient, because of relatively wet seasons which have persisted since its construction. Nevertheless, its availability has been a source of comfort to the Borough waterworks officials who are responsible for meeting an abnormal demand with little or no spare capacity. During the war, also, equipment was provided for pumping chlorinated raw water into the system when peak loads overtax the filter plant. This equipment was frequently used.

The Borough dam is founded on pervious material and substantial loss by seepage occurs. This seepage, previously inconsequential, became important as demand rose during the war. To reclaim this lost water, a low cut-off with wood sheeting driven to impervious material was built across the brook, about 800 ft below the dam. This structure intercepts the leakage, much of which at this point has come to the surface, and backs it up in the old tailrace, whence a vertical pump can return it to the reservoir. Continuing wet seasons have made the use of this facility unnecessary, but the gate structure built at the cut-off has furnished an opportunity for the installation of V-notch weirs for the measurement not only of seepage loss, but also of all flows passing down the stream. This has enabled the tabulation of complete runoff data for this watershed. This information is not only valuable for our own purposes but adds to the store of such data on Connecticut streams.

Since the filter plant is nearly 3 miles from the more populous part of the Borough, transmission mains have been an important problem as demands have increased. All through the war a 10-in. and a 16-in. main, parallel part-way and by separate routes the remainder, had to carry the load. Friction losses at the high rates limited the capacity of our pumps and severely taxed the ability to meet peak demands. At the outset only one small (300,000-gal) standpipe of ancient vintage provided an inadequate reserve to balance fluctuations. This was augmented in 1942 by 1,480,000 gal in a prestressed concrete reservoir, located in the northerly part of our rectangular distribution grid, and

again in 1947 by 1,460,000 gal in a steel standpipe, located in the southerly part of the grid. Water levels in the standpipes and reservoir are transmitted to the filter plant by telemeter, and this information assists the operator in planning operation and pumping to follow the demand most advantageously.

Notwithstanding these units of elevated storage, the need for additional supply-pipe capacity was still keenly felt and in 1948 a new 20-in. main was completed. This line, constructed of Lock-Joint, steel-cylinder, prestressed concrete pipe, was carried to the southerly part of the Borough, terminating near the Pfizer plant, which will be the largest single user of water. It is connected with the other elements of the system at appropriate points.

Concrete pipe was chosen because of earlier availability, lower cost, and permanence of carrying capacity. It is not so easy to tap as, for example, cast iron, but it can be done. This pipe is essentially a supply main and tapping should seldom be necessary. So far as could be anticipated blank outlets were built into the line for future connections.

Concrete pipe adds one more to the various types of pipe and joints which can be found in our mains. Several sections of the distribution system were bequeathed to us by the Federal government in war-time housing developments, with a resulting variety of both materials and workmanship. However, the system has been gradually coördinated and, under the watchful eye and skillful hands of our capable field staff, our 40-odd miles of mains serve the major part of our area adequately. Additions to the distribution grid are made from time to time as need arises.

The book value of the Groton Water Works is nearly $2,000,000, including the cost of the new filter plant. An investment of this magnitude in a community of moderate size justifies the painstaking attention which it has received from successive Boards of Utility Commissioners. The present Board consists of Warden Arthur M. Card; Commissioners James A. Ward, John L. Couch, Henry Gamber and Lewis P. Bailey, and Superintendent Lendon F. Dutton. Under their authority comes also the administration of the municipal light and power system and the sewer system.

The water and electric departments are self-supporting and in

the war years were able to contribute substantial sums in aid of Borough financing. The service of the debt incurred for new works now under construction and contemplated, together with the rising costs with which you are all familiar, forces us to give serious consideration to our water rates, which may have to be revised upward. In this we are no different from most water-works utilities.

We look forward to a period of business prosperity in this locality and we are confident that, with the developments to which we are now committed and with the plans which are in our future program, our water works will be able to keep abreast of the ultimate demands of foreseeable growth.

A DECADE OF OPERATING EXPERIENCE AT THE GROTON FILTER PLANT

BY A. C. GREENLEAF*

[*Read April 21, 1949.*]

THE water-filtration plant of the Borough of Groton, Conn., was completed and put into operation in the fall of 1939. A description of the plant and of its first year's operation will be found in the JOURNAL of the New England Water Works Association for 1941, page 233.

The source of supply for the filter plant is an impounding reservoir, fed by Great Brook, which drains an area of about 14 sq mi. The water in the reservoir is high in color and is subject at times to tastes and odors due to algae. Although no serious source of contamination exists on the watershed, there are numerous houses thereon, and opportunities for accidental and intermittent pollution exist. Prior to the construction of the filter plant the supply was chlorinated.

The present facilities for treatment of the supply include provision for aeration by compressed air, dry-feed chemical feeders, paddle-agitated mixing and coagulation tanks, sedimentation basins, rapid sand filters, clear-water basin, and chlorinators for pre- and post-chlorination. The raw water is low in alkalinity and it is necessary to add lime to the raw water, in order to provide alkalinity to react with the filter alum used as a coagulant. Lime or soda ash is also applied to the filtered water as a corrosion-control measure.

In the early years aeration was used to a limited extent, but in recent years it has not been used at all. The benefits of compressed-air aeration did not appear sufficient to warrant the cost of power for operating the compressor.

The chemicals used for coagulation have been alum and lime. As stated above, the lime has been required due to the low alkalinity of the raw water. In recent years the chlorine dosage used in pre-chlorination has been quite high. This high chlorine dosage has apparently been of value in assisting coagulation, in preventing septic

*Chief Operator, Filter Plant, Groton, Conn.

TABLE 1.—MONTHLY SUMMARY OF CHEMICAL DOSAGES AT WATER-FILTRATION PLANT, GROTON, CONN.

Month	Alum	Pre lime	Post lime	Post soda ash	Carbon	Pre chlorine	Post chlorine
			Pounds per million gallons				
1946							
Jan.	218	50	94	193	0	0	4.3
Feb.	186	44	0	206	0	0	5.5
Mar.	175	37	0	183	0	0	8.3
Apr.	171	27	0	162	0	0	9.9
May	147	18	0	222	0	11.4	10.8
June	180	18	0	276	0	12.6	11.8
July	136	0	123	281	0	18.5	11.0
Aug.	161	21	133	0	0	25.9	11.2
Sept.	196	22	139	0	18	31.4	11.4
Oct.	198	29	105	0	17	31.2	11.7
Nov.	207	37	99	0	0	38.6	12.1
Dec.	193	36	86	0	0	31.1	5.6
1947							
Jan.	170	32	53	0	0	18.7	4.0
Feb.	184	39	76	0	0	17.6	3.6
Mar.	185	46	72	0	0	19.2	3.7
Apr.	188	43	78	0	0	23.3	4.3
May	174	33	95	0	0	28.9	4.8
June	168	19	119	0	0	35.5	6.4
July	145	15	135	0	0	30.2	6.1
Aug.	131	0	126	0	0	30.7	6.3
Sept.	112	0	103	0	0	26.4	5.6
Oct.	108	0	85	0	0	19.8	4.8
Nov.	186	50	105	0	0	26.9	4.9
Dec.	211	59	76	0	0	22.0	4.7
1948							
Jan.	170	32	140	0	0	18.3	3.9
Feb.	173	34	138	0	0	16.8	3.1
Mar.	177	50	85	0	0	12.7	3.0
Apr.	176	50	87	0	0	17.4	3.4
May	179	42	78	0	0	25.0	4.0
June	215	59	95	0	0	30.0	3.9
July	188	32	124	0	0	29.6	4.9
Aug.	153	20	128	0	0	29.2	4.9
Sept.	115	0	104	0	0	24.9	5.0
Oct.	110	0	98	0	0	19.6	4.9
Nov.	114	0	105	0	0	17.2	4.1
Dec.	149	26	103	0	0	19.1	4.5

decomposition of the sludge in the settling basins, and in keeping the filter sand in good condition, thereby increasing filter runs and decreasing volumes of wash water. On a few occasions activated carbon has been used for taste and odor control, but generally it has not been needed. Due to the corrosive character of the filtered water, it has been necessary to apply corrective measures by the addition of lime or soda ash to the final effluent—usually lime. Final chlorination has also been practiced, the dosage in recent years being relatively high in order to maintain a residual throughout the distribution system. Monthly summaries of chemical dosages for the past three years are given in Table 1 and yearly summaries for the past ten years are shown in Table 2.

TABLE 2.—YEARLY SUMMARY OF CHEMICAL DOSAGES AT WATER-FILTRATION PLANT, GROTON, CONN.

Year	Alum	Pre lime	Post lime	Post soda ash	Carbon	Pre chlorine	Post chlorine
			Pounds per million gallons				
1939	117	0	63	0	15	8.4	2.5
1940	195	33	79	0	12	8.4	3.2
1941	138	32	82	0	0	10.2	3.3
1942	161	31	92	0	17	9.3	3.5
1943	162	26	94	0	0	10.0	3.2
1944	173	26	95	0	11	8.8	4.1
1945	153	25	89	0	13	8.8	3.9
1946	180	28	112[1]	217[1]	17[2]	16.7	9.5
1947	164	28	94	0	0	24.9	4.9
1948	160	29	107	0	0	21.7	4.1

[1] 7 months
[2] 2 months

The filters were designed to operate at the conventional rate of 125 mgad (million gallons per acre daily), at which rate their capacity is 2.0 mgd. During the war years the water consumption increased greatly, with the result that the filters were operated considerably in excess of their rated capacity. Filter rates in excess of 175 mgad occurred at times and rates of 150 mgad have been frequent over the past six years. Even with these high rates the plant has functioned efficiently. Wash-water volumes have been moderately low and filter

TABLE 3.—MONTHLY SUMMARY OF FILTER OPERATION AT WATER-FILTRATION PLANT, GROTON, CONN.

Month	Total filtered (mgd)	Wash water (%)	Net yield (mgd)	Rate of filtration (mgad)	Ave. length of filter runs (hours)	Ave. loss of head	
						Initial	Final
1946							
Jan.	2.224	3.67	2.142	160.16	17.97	1.32	3.85
Feb.	2.104	2.94	2.042	144.57	26.62	1.16	4.91
Mar.	1.995	2.68	1.941	137.00	30.72	1.02	7.17
Apr.	2.007	3.35	1.939	137.00	28.73	0.95	9.76
May	2.007	4.62	1.914	138.00	21.60	1.00	10.10
June	2.155	3.43	2.081	150.78	25.75	0.97	9.04
July	2.357	3.32	2.278	166.27	22.03	0.97	9.27
Aug.	2.150	4.02	2.063	161.75	19.70	0.95	9.42
Sept.	2.067	3.64	1.990	146.88	22.65	0.82	9.83
Oct.	1.883	3.83	1.811	144.27	23.37	0.93	10.13
Nov.	1.673	3.87	1.611	126.32	26.92	0.87	10.51
Dec.	1.869	3.37	1.806	141.21	27.11	1.09	10.09
1947							
Jan.	1.732	2.76	1.684	140.13	32.09	1.03	9.64
Feb.	1.679	2.20	1.642	124.00	52.48	0.91	10.19
Mar.	1.663	1.96	1.631	126.00	55.37	0.90	10.61
Apr.	1.616	2.35	1.578	124.00	47.67	0.77	11.05
May	1.725	3.05	1.672	124.00	39.73	0.69	10.75
June	1.867	3.33	1.804	126.62	32.62	0.68	10.97
July	2.214	3.61	2.135	151.32	26.46	0.76	9.55
Aug.	2.176	3.88	2.092	149.00	24.07	0.75	9.86
Sept.	1.929	3.86	1.854	149.00	23.59	0.75	10.04
Oct.	1.781	3.67	1.716	144.87	23.37	0.81	9.30
Nov.	1.715	3.33	1.658	124.00	30.02	0.79	7.82
Dec.	1.701	2.84	1.653	124.00	33.35	0.82	5.02

TABLE 3.(*continued*)

Month	Total filtered (mgd)	Wash water (%)	Net yield (mgd)	Rate of filtration (mgad)	Ave. length of filter runs (hours)	Ave. loss of head Initial	Final
1948							
Jan.	1.800	2.29	1.758	124.00	40.89	0.85	6.56
Feb.	1.880	2.36	1.835	124.00	42.89	0.86	6.00
Mar.	1.867	2.05	1.828	125.86	47.27	0.88	5.47
Apr.	1.834	2.08	1.795	127.75	47.66	0.79	7.11
May	1.906	2.24	1.863	144.63	41.65	0.85	9.08
June	2.436	1.85	2.391	174.00	40.12	1.01	8.26
July	2.468	2.42	2.400	172.50	31.39	0.95	9.54
Aug.	2.584	2.88	2.475	174.00	25.41	0.96	9.36
Sept.	2.362	3.57	2.278	168.78	19.99	0.97	9.75
Oct.	1.986	3.15	1.923	149.00	26.21	0.95	9.74
Nov.	2.008	2.59	1.955	149.00	31.44	1.02	9.83
Dec.	2.030	2.61	1.977	149.00	30.53	1.11	9.41

TABLE 4.—YEARLY SUMMARY OF FILTER OPERATION AT WATER-FILTRATION PLANT, GROTON, CONN.

Year	Total filtered (mgd)	Wash water (%)	Net yield (mgd)	Rate of filtration (mgad)	Ave. length of filter runs (hours)	Ave. loss of head Initial	Final
1939	0.752	4.43	0.719	102.61	26.46	1.12	10.48
1940	0.903	4.16	0.866	119.29	29.25	1.07	9.75
1941	1.113	3.76	1.071	124.00	27.41	1.05	9.89
1942	1.523	3.91	1.463	124.08	27.18	1.06	10.16
1943	2.256	3.65	2.174	152.33	23.61	1.25	9.69
1944	2.482	4.02	2.382	169.53	18.54	1.31	9.15
1945	2.525	3.39	2.438	173.44	19.48	1.26	8.14
1946	2.041	3.56	1.968	146.18	24.48	1.00	8.67
1947	1.816	3.07	1.760	133.91	35.07	0.81	9.57
1948	2.094	2.51	2.039	148.55	35.45	0.93	8.34

runs have been long. Sand expansion has varied from about 25% to 50%, according to temperature of the wash water. The vertical rise of the wash water during washing approximates three feet. The settling basins have been cleaned about every two to three months, the sludge as well as the filter wash-water being discharged into the brook below the reservoir. Table 3 gives monthly summaries of filter operation for the past three years and Table 4 gives yearly summaries for the past ten years.

The color of the raw water is of variable intensity, at times being high and always in excess of the desirable limit. The water is naturally soft and corrosive. At times growths of algae tend to produce undesirable tastes and odors. Bacterially the raw water is good for a surface supply, although coliform organisms are usually present in the 10-ml inoculations. The final effluent has been invariably of excellent physical, chemical and bacterial quality, as shown by the analytical data. Monthly summaries of physical and chemical characteristics of the raw water and of the water as delivered from the plant are shown for the past three years in Table 5, and yearly summaries for the past ten years in Table 6. These analyses are made by the writer at the laboratory of the filter plant. Bacterial analyses of the filtered water are made several times a year by the State Department of Health. A few bacterial analyses of the raw water have also been made. Of the 121 samples of delivered water examined since the plant was first put into operation and prior to the first of March, 1949, not one gave positive results for coliform organisms in any of the 10-ml inoculations examined. The average most-probable-number of coliforms in the raw water during the same period, based upon the analysis of 13 samples, was 31 per 100 ml.

Special attention is called to Table 4, the yearly summary of filter operation. This table gives an excellent picture of the benefits of pre-chlorination. Prior to February, 1946, pre-chlorination was used only during the summer months, when water temperatures and colors were high and bacterial loads were heavy. Pre-chlorination has been continued without interruption since that date. After that date, it will be noted that filter runs increased and the percentage of wash water decreased considerably. The cost of additional chlorine is well repaid in the benefits derived.

TABLE 5.—MONTHLY SUMMARY OF PHYSICAL AND CHEMICAL ANALYSES AT WATER-FILTRATION PLANT, GROTON, CONN.

Month	Water temp. (°F.)	Color		pH		Carbon dioxide		Alkalinity		Hardness	Chlorine residual
		Raw (ppm)	Tap (ppm)	Raw	Tap	Raw (ppm)	Tap (ppm)	Raw (ppm)	Tap (ppm)	Tap (ppm)	Tap (ppm)
1946											
Jan.	36.7	39.9	7.3	5.9	8.0	11.6	1.0	4.8	23.1	35.5	0.18
Feb.	37.0	31.4	5—	5.9	8.0	10.8	1.0	5.0	27.1	29.9	0.28
Mar.	45.0	32.6	5—	6.0	8.1	8.1	0.3	5.2	23.3	27.5	0.65
Apr.	51.4	35.9	5—	6.3	8.1	5.5	0.3	6.0	20.6	27.6	0.74
May	60.4	50.4	5—	6.6	7.9	7.5	1.6	7.9	26.0	25.3	0.65
June	66.2	78.6	5.3	6.4	7.6	12.2	3.3	8.4	31.5	24.4	0.50
July	74.2	69.6	5—	6.6	7.8	8.5	1.5	10.7	24.5	36.9	0.72
Aug.	70.9	73.0	7.7	6.6	8.0	8.5	0.3	9.6	20.9	50.5	0.90
Sept.	68.0	78.6	7.5	6.6	8.0	10.2	0.5	9.7	21.3	52.1	0.96
Oct.	59.2	59.8	5.1	6.8	8.0	3.9	0.1	9.3	17.3	46.6	0.85
Nov.	49.4	51.6	5—	6.8	8.0	3.1	0.2	8.5	16.3	43.1	0.98
Dec.	37.8	43.8	5—	6.8	8.0	2.8	0.2	8.1	14.6	40.4	0.69
1947											
Jan.	38.5	34.1	5—	6.6	8.0	4.3	0.2	7.3	15.9	39.3	0.37
Feb.	37.4	35.8	5—	6.7	8.1	3.1	0.0	5.3	13.7	37.6	0.25
Mar.	40.4	33.3	5—	6.7	8.1	2.7	0.0	4.0	12.8	34.8	0.27
Apr.	50.1	42.2	5—	6.7	8.1	3.1	0.0	4.0	12.9	36.0	0.27
May	59.0	55.4	5—	6.7	8.1	3.7	0.0	6.1	15.3	35.4	0.25
June	67.2	68.6	5—	6.7	8.1	3.8	0.1	8.4	18.1	39.1	0.28
July	75.9	69.6	5—	6.6	8.1	5.5	0.1	9.4	20.5	39.0	0.26
Aug.	76.0	57.4	5—	6.8	8.1	3.6	0.0	9.7	19.2	36.8	0.28
Sept.	70.6	35.2	5—	6.8	8.1	3.1	0.0	9.5	17.4	33.9	0.31
Oct.	59.6	30.7	5—	6.8	8.1	2.6	0.0	9.2	15.5	32.3	0.31
Nov.	44.2	54.2	6.8	6.6	8.1	3.0	0.1	5.5	15.2	42.6	0.31
Dec.	37.6	47.6	5—	6.5	8.1	3.2	0.1	3.6	13.2	45.9	0.40

TABLE 5. (*continued*)

Month	Water temp. (°F.)	Color Raw (ppm)	Color Tap (ppm)	pH Raw	pH Tap	Carbon dioxide Raw (ppm)	Carbon dioxide Tap (ppm)	Alkalinity Raw (ppm)	Alkalinity Tap (ppm)	Hardness Tap (ppm)	Chlorine residual Tap (ppm)
1948											
Jan.	37.6	39.3	5—	6.3	7.9	9.3	0.9	5.6	21.6	50.9	0.39
Feb.	34.8	36.1	5—	6.2	8.0	7.4	0.4	5.5	21.4	50.6	0.38
Mar.	37.9	32.0	5—	6.4	8.1	4.0	0.0	3.7	15.2	45.2	0.29
Apr.	51.2	37.4	5—	6.6	8.1	2.7	0.0	4.6	11.0	41.6	0.23
May	59.3	52.3	5.3	6.6	8.0	3.1	0.1	6.0	12.4	43.7	0.26
June	65.1	78.5	5.4	6.5	8.0	5.4	0.2	7.3	15.7	47.0	0.29
July	74.4	86.3	5.5	6.6	8.0	7.1	0.2	10.1	21.1	48.0	0.23
Aug.	75.5	64.2	5—	6.7	8.1	4.0	0.1	10.7	19.1	43.0	0.28
Sept.	69.5	36.4	5—	6.9	8.1	2.6	0.0	10.4	17.0	39.1	0.36
Oct.	56.2	32.0	5—	6.9	8.1	2.2	0.1	9.5	15.8	36.6	0.42
Nov.	50.3	29.9	5—	6.9	8.1	2.4	0.1	8.9	15.6	39.2	0.39
Dec.	39.0	32.5	5—	6.7	8.1	2.8	0.1	6.2	15.0	48.4	0.32

TABLE 6.—YEARLY SUMMARY OF PHYSICAL AND CHEMICAL ANALYSES AT WATER-FILTRATION PLANT, GROTON, CONN.

Year	Water temp. (°F.)	Color Raw (ppm)	Color Tap (ppm)	pH Raw	pH Tap	Carbon dioxide Raw (ppm)	Carbon dioxide Tap (ppm)	Alkalinity Raw (ppm)	Alkalinity Tap (ppm)	Hardness Tap (ppm)	Chlorine residual Tap (ppm)
1939	—	33.2	7.9	6.7	7.2	3.9	2.1	8.0	11.2	32.2	0.11
1940	—	50.5	—	6.5	7.4	8.2	2.1	7.2	13.5	39.2	0.13
1941	—	39.0	—	6.7	7.9	5.7	0.6	7.2	13.9	33.5	0.13
1942	—	49.0	—	6.7	8.0	7.5	0.5	7.6	15.7	43.5	0.13
1943	—	45.1	—	6.7	8.1	6.4	0.1	5.8	16.1	44.7	0.13
1944	—	48.6	—	6.7	8.2	9.0	2.0	7.8	16.9	40.5	0.15
1945	—	43.6	6.3	6.6	8.1	8.6	0.2	7.9	16.6	38.1	0.16
1946	54.7	53.8	5.7	6.4	8.0	7.7	0.9	7.7	22.2	36.5	0.67
1947	54.7	47.0	5.1	6.7	8.1	3.5	0.1	6.8	15.8	37.7	0.30
1948	54.2	46.8	5.1	6.6	8.1	4.4	0.2	7.4	16.8	44.5	0.32

Routine weekly examinations are made for microscopic organisms. If an increase of organisms is noted, samples are collected from the reservoirs, to find the points of concentration, and steps are then taken to control them. A supply of copper sulphate is on hand at all times for this purpose.

Much credit for the continued fine results in the operation of this plant is due to the excellent design by Metcalf & Eddy, the supervision of Mr. L. F. Dutton, and the assistance of an able crew of operators.

REVITALIZING OLD WATER SYSTEMS

BY KENNETH H. HOLMES*

[*Read April 21, 1949.*]

THE revitalizing of our water systems is a subject that has at some time confronted, or will at some time in the future confront, most water-works men. It is hard to follow the trends of municipal growth accurately enough to plan 25 or even 15 years ahead. Hence it is necessary to rebuild our systems from time to time so as to give proper service to our customers, both in the domestic and commercial fields, and also to provide proper fire protection for the community. Changes may come about in the growth of a municipality where the mere transfer of title of a large tract of land and the resulting construction of factories and a large governmental agency would upset the normal flow and main capacity of our entire system. These changes may come about in an area which previously had been thought of as a purely residential site and where the main construction had been gridded to that end.

Before going into the results of raising the head 110 ft on our 100 miles of transmission and distribution mains, it would seem proper that we take a few minutes to outline the history of the New London Water Works.

"The General Assembly of the State of Connecticut, May session of 1871, passed a special act, approved July 5th, 1871, entitled 'an act to provide the City of New London with a supply of pure and wholesome water'.

"The plan of the public water supply evidently originated with Mr. William H. Barns, who, as president of a newly formed board of trade, engaged Mr. J. T. Fanning, who had recently completed the Norwich water works, to make the necessary surveys. These were started by Assistant Engineer Walter H. Richards early in June, 1871.

"The whaling business on which the City had been mainly dependent, ruined by the Civil War, was falling into decay and such manu-

*City Engineer, 31 Brook Street, New London, Conn.

facturing as had started before the war was suffering under the depression. The only water works the majority of the citizens were acquainted with was the log pipe system, built in 1801 from springs on the Norwich road, which had been abandoned for a supply from the Mill pond and a supply from springs under the Wilson Works down Golden Street to the wharves. Under these circumstances the expenditure of $185,000.00 seemed a staggering proposition.

"Strong opposition to the whole plan developed and the old Court House rang with eloquence of the opposing parties. The records show that there was abundant opposition, one citizen publishing the statement that the Nameaug engine could pump more water than ran from the lake, another (who registered a bet with the engineer that he would not live long enough to see water run over the dam) was drowned in the water when it did run over.

"The water was turned on January 1, 1873, but owing to improper methods of laying the pipe by the contractor, numerous leaks developed in the supply main and had to be repaired. The contractor took care of this during the summer. The original mains were constructed entirely of cement-lined wrought-iron pipe, due largely to the high price of cast-iron pipe, which in 1872 was about the same as during the World War I. The use of this pipe has been generally abandoned, with the fall in the price of cast iron. These cement-lined mains have since been replaced with larger mains of cast-iron pipe.

"The method necessarily used in construction of both the mains and dam would have appalled a contractor nowadays. Few of the modern construction tools were in existence; the ditch pump, run by gasoline, was unknown. Blasting was done with black powder, although nitro-glycerine, procured from the naval station at Newport, was used at Douglass Hill, being landed from the vessel at Pequot wharf and carted to Douglass Hill in the night. The steam drill was used to some extent. All Portland cement had to be imported and the tile pipe, which is so common today, was imported from Scotland.

"About the year 1884, the number of bursts in cement-lined mains began to reach large proportions. They resulted in a shower of stones and muddy water, pointed in unexpected directions, and if an open window or door was in the way, the occupant of the building was in a poor frame of mind to make a settlement for damages easy.

"The first years of the collection of regular rates for families and fixtures were attended with much argument—where a house or tenement was vacant a month, abatement was demanded. One party objected to paying rates on a bathtub because it had been used only as a coal bin; another kept his bathroom locked. The threat to shut off the water, if the bill remained unpaid, has always been resisted by certain people and often was deemed insulting. One person who had been shut off called a city meeting to lower the superintendent's salary. The first complaint has been obliterated by the installment of meters; the second, while still existing, has been found to be confined to certain persons with whom it is chronic.

"In 1885, bursts and leaks in the cement-lined mains had increased and all extensions thereafter were made with cast-iron pipe.

"Mr. William H. Barns died in 1886. It has been said of him that 'to his indomitable will and untiring energy the city is indebted for its system of water works;' he unceasingly gave freely of both time and energy to the undertaking. He always viewed the water works as an investment made by the city and from which a reasonable income should be derived.

"With the rapid extensions and the consequent increase in use, the draft was increased until, at the end of 1901, it amounted to over two and a half millions of gallons per day. The engineer reported to the Board in January, 1901, the imminence of a water famine and, in spite of curtailment in the use of water, it was necessary to set up a pump in the meadow below Lake Konomoc and pump into the lake for a month, when extraordinary rainfall occurred which increased the supply to a point of temporary safety. The rainfall in the months of March, April and May amounted to over 26 inches or over half the average for a whole year. Thus, by a most unusual occurrence, was a serious water famine averted.

"The Board, immediately upon receiving the engineer's report, took steps to permanently increase the supply. Miller's pond was first considered and negotiations opened with the owners of the water rights, but were blocked by the extravagant price asked by one owner, who insisted on receiving $75,000.00 for rights since sold for speculative purposes for $20,000.00 and, as time did not permit the prolonged proceedings of condemnation, it was necessary to turn to Carr's pond

brook supply. After hurried surveys and estimates, it was decided to build the Barns reservoir.

"In 1903, the new high service No. 2 was built, the draft of water on the high ground having increased beyond the capacity of the first plant. This plant consisted of a reservoir holding 500,000 gallons, on the highest ground in the city, in the rear of Connecticut College. The flow line is 253 feet above tide and 75 feet above Lake Konomoc, ground enough being purchased for another reservoir of the same size in the future. The reservoir is supplied by pumps taking water from the low-service pipes. These pumps are located on Mill Street, driven by power derived from Briggs Brook reservoir before described, thus utilizing the reservoir and pipes from this reservoir which before was lying useless. In case of a failure of power from this supply, electric motors are provided.

"The Bogue Brook reservoir, completed in 1920, was authorized by a vote of the city in 1901. The foundation for the dam of this reservoir, like that of Barns reservoir and Lake Konomoc, was very difficult and required much careful thought and experiment.

"The Board in April, 1919, voted to install meters on all service pipes in the city, including those used to supply public and semi-public uses, and to charge for all water used, except that used for fire purposes. Thus, by metering and charging for all water, special privilege is obliterated, all being served alike, obliterating at one stroke a great injustice. For appreciating this principle and bringing it into effect, the public is largely indebted to Commissioner Morris B. Payne.

"In June, 1905, the water and sewer department boards were consolidated and in the succeeding year the City failed to appropriate any money for maintenance or construction of sewers. As a consequence, the avails of water rents were used to maintain and extend the sewers, until at the present time the water rents invested in sewers amount to $118,000.00.

"The 1921 administration appropriated for maintenance of sewers for the first time since consolidation. The story of the sewer department, of which Mr. Richards was engineer from the beginning, remains to be told.

"On about January 1st, 1922, three very important things occurred with relation to the Water Department: a new uniform system

of accounting was adopted by the Public Utilities Commission of the State; the Board of Water Commissioners was abolished and Mr. Walter H. Richards retired as Chief Engineer; his duties being assumed by Mr. George E. Waters, his assistant, and the department was from that time operated under the Department of Public Works—Division of Engineer and Water. Mr. Waters died on June 3, 1940, and Mr. Kenneth H. Holmes was appointed City Engineer and, at the present time, acts as Superintendent of the Water Department, assisted by Mr. Charles W. Harvey.

"Due to the increase in service on the high-service section of the City, and the addition of mains to the Coast Guard Academy, an increase of the storage at the high-service reservoir was necessary, as well as the addition of more pumps and the construction of a new pump line to the reservoir. This work was completed in 1931 at a cost of about $75,000.00. With the installation of the new pumping station at Lake Konomoc, the pumping formerly done at the Mill Street station has been discontinued and this station is being held for engineering use only."

At the time of Mr. Waters' death in 1940, there was contemplated a revamping of the high-service system, which at that time had grown to about 35% of the total water consumption. This in itself was not a problem, but the fact that the pump station was located in the heart of the city on one of the feeder mains made adding more pumps impossible, due to the fact that each additional gallon taken from the low-pressure or gravity system lowered the head and brought about a problem in the higher or border-line areas of the low-pressure system. It would then be necessary to add these critical areas to the high service and begin an endless spiral of robbing Peter to pay Paul.

At that time, we ran the high-service pumps very sparingly during the daylight period and filled our balancing reservoir at night. We were continually either pumping up the pressure in the high-service system or shutting off pumps to give more water to the areas in the low-pressure system.

Another problem was also confronting us in the fact that some of the parts of the transmission mains were laid on or just under the hydraulic grading for a 4-mil gal flow through the two mains, and at times of peak loads the demand ran as high as a rate of 7 or 8 m.g.d.

Therefore, if a large pump station were built in town, it would then be necessary to lay a new main from the lake to the pump station and leave the other two mains to feed the low-pressure districts. To save the expense of the 7 miles of the new main, it was suggested that the pump station be placed at the lake, with balancing tanks to raise the whole system to a higher pressure. This would raise the head as well as the hydraulic gradient on the transmission mains and in that way provide better flow to the city. This plan was approved by Council in 1941; the plans were drawn by Clarence Blair of New Haven, and the construction work was done by N. Benvenuti and Sons, Contractors, of New London.

The work embraced in this construction project is described in the following report made by Courtland Darrow, who was the author's assistant at that time. Thus due credit is given to Darrow and to Guy Susi, the inspector on the work.

"A new *gate chamber;* a suction line from gate chamber to pumping station; *a pumping station;* three *concrete storage tanks;* a *supply line* from storage tanks to connect with present mains below the dam; a line of *transite pipe* to take water from two upper reservoirs, now discharging into upper end of main reservoir, to a direct connection with suction line, and installation of one and one half miles *6-in.* and *10-inch cast-iron cross-grid connections* in the City.

"The gate house is located on the west side of the main reservoir about one third of a mile above the dam.

"This structure is of concrete 24 ft. x 24 ft. in size located about 150 ft. from the shore in about 25 ft. of water. Prior to the construction, the reservoir was drawn down six and one half feet to facilitate the work.

"Since the grade of the suction line called for a cut of about 21 ft. adjacent to the reservoir the contractor elected to fill out to the site of the gate house. Steel sheet piling 30 ft. long was then driven around the foundation enclosing a square 32 ft. x 32 ft. This area was then excavated by dredging to a depth of 27½ ft. below the flow line and a concrete mat 32 ft. x 32 ft. x 4 ft. was poured, using a tremie. When this was set the excavation was pumped out and forms for the house constructed. The sidewalls are 3 ft. in thickness with a cross wall 3 ft. in thickness separating the inlet and suction wells on the east side

from those on the west side, making two independent units. Each unit consists of two wells separated by a screen wall 5′-3″ in thickness with an opening near the bottom covered by screens. Vertical grooves are provided to permit these screens to be raised and lowered by means of winches and counter-weights in the superstructure.

"There are two intake openings in each unit located 4 ft. and 14 ft. above the floor in the east well and 8 ft. and 18½ ft. above the floor in the west well. These openings are formed by 20-inch x 24-inch cast-iron increasers with the outer face formed in the concrete to receive bar screens. On the inside are 20-inch valves operated from the floor of the superstructure.

"The suction pipe in each suction well is 20-inch cast iron, located 19 ft. above the floor and 4½ ft. below the flow line of the reservoir when full. A quarter bend, a 12-ft. length of pipe, and a foot valve extend down to a level 3 ft. above the floor of the well. The superstructure of the gate house is of brick with precast concrete joist supporting the roof. The suction line consists of two 24-inch cast-iron pipes, from the intake gate house to the pumping station on the West side of the Hartford Turnpike, a distance of about 1,075 ft. The grade of this required a cut of about 21 ft. for a distance of about 500 ft.

"As the fill for the gate house required about 3000 cu. yd., the contractor made a wide cut about 12 ft. deep, using this material for the gate-house fill. Most of the remaining cut was made in the open and the material placed on the berm left by the excavation. At the Hartford Turnpike crossing, steel sheet piling was used, keeping one-half of the roadway open for travel. As the greater part of this excavation was in fine sand and the grade near or below the permanent water table, much difficulty was encountered by caving as shown by accompanying photograph.

"The 20-inch transite line to take the water from the upper reservoirs directly to the suction line, a distance of about one and one-halt miles, was laid along the West side of the main reservoir and presented no particular difficulties other than the difficulty of getting delivery of the pipe and rubber gaskets needed.

"The pumping station situated on the westerly side of the Hartford Turnpike about 1,075 ft. from the gate house is of concrete construction and concrete faced with precast stone face.

"The suction pipe enters the pumping station at an elevation 1½ ft. higher than the gate-house end, and 3 ft. lower than the flow line in the main reservoir. The main pump room, chlorine and ammonia rooms, shower and toilet rooms are lined with ceramic glaze tile. The roof is supported by pre-cast concrete joists.

"The pumping equipment consists of four Murphy diesel engines, 96 H.P. each, equipped with electric starting system and generator. The four centrifugal pumps have a capacity of 1750 G.P.M. each under 145 ft. head.

"In the pipe gallery are two Venturi Meters.

"In the chlorine room are two chlorinators of automatic-control solution-feed vacuum type. There are two 24-inch cast-iron transmission mains from the pumping station to the standpipes about 800 feet westerly.

"*Standpipes.* There are three concrete standpipes on a hill west of the pumping station. They are 90 ft. inside diameter and 35 ft. in height with a capacity of 1,500,000 gallons each. The site was leveled off to elevation 261 or 82½ ft. above the flow line of the reservoir. A 12-inch sand cushion was placed as a foundation for the concrete. Upon this was laid an electric-welded steel mat of 3/16-inch wire spaced 6 inches apart each way and around the rim were ½-inch bars 4 ft. long spaced 15 inches apart, bent at right angles to extend into the floor and into the side walls of the tanks.

"All of the concrete in the tanks was placed by compressed air, using two compressors having a capacity of 250 cu. ft. of air per minute at 40 lb. pressure. The specifications required the proportions of the ingredients and the method of placing to be such as to give a 28-day compression strength of at least 5000 lb. per sq. inch in the floor and side walls and 4000 lb. per sq. in. in the roof.

"The design of the tanks submitted by the Pre-Load Co. of Boston, sub-contractors, calls for a floor 2 inches thick, side walls 14 inches thick at the base and 4 inches thick at the top and a domed roof 2 inches thick.

"After the steel floor mat was in place, concrete was deposited, the mat being raised just ahead of the nozzle so that it was incased in the concrete. As a rule not more than 1 inch in thickness of concrete was deposited at one time.

"After the floor was in place, the outside forms were erected. These were made of ⅞" matched boards. They were made up in sections 6 feet wide by 12 ft. high nailed to horizonal strips cut to the proper radius, there being 4 of the horizontal strips to each panel. These panels were then assembled around the outside perimeter of the tank and given the proper batter. Three rings of panels were required to give the required height of tank. A small opening was left at the base for the passage of workmen and removal of rebound material. When this form was in place and properly guyed the vertical reinforcing steel for the side walls was put in place. This consisted of ⅝" steel rods spaced 18 inches apart made into loops, three rods about 25 feet long joined by turnbuckles being required to make one loop. These loops were then hung from the top of the forms, allowance being made for the top of the loop to be built into the dome and the bottom into the thickened base adjoining the sidewalls. These loops were so bent that one of the turnbuckles would be incased in the sidewall about one-third of the distance from the floor to the top and the other about two-thirds of this distance. These turnbuckles were wrapped with waterproof paper to exclude the concrete and permit taking up on them to give the rods the proper stress after the removal of the forms.

"After the rods were in place, the same kind of electric-welded wire mesh as that used in the floor was hung all around the tank and wired to the rods so as to give the proper distance from the forms.

"Shooting of the concrete against the forms was then begun in layers of about one inch at a time. A frame, having platforms at different levels, and mounted on castors, was used by the men operating the nozzle. This was moved around on the floor as required. Vertical guide wires at 6-ft. intervals were hung around tank so that the nozzle operator could get the proper thickness of concrete. After the walls were of sufficient thickness to permit it, the outside forms were taken down and re-erected for the second tank, while the nozzle man continued work on the inside.

"Three rings of 1⅛-inch rods connected by turnbuckles were placed around the tank at the top which were taken up to give the proper stress.

"After the removal of the side-wall forms the waterproof paper around the turnbuckles in the vertical rods was removed, the turnbuckles taken up, and the space shot full of concrete.

"Erection of the forms for the construction of the dome was then started. When this was in place the reinforcing steel, consisting of the same kind of mat as used in floor and walls, was placed and the concrete shot to the required thickness of two inches.

"The turnbuckles in the 1½-inch rods around the top were then taken up to give the proper stress of 40,000 lb. per sq. in. This raised the concrete in the dome slightly off of the forms and facilitated the removal.

"The form lumber in the dome of the first tank was taken out through the hatchway in the roof and carried across a bridge to form a roof form for the second tank, the framing for which had been previously placed.

"The three outside horizontal steel rings at the top were then covered with concrete. The horizontal reinforcement for the tank was put in place by a machine which traveled around the outside wall. This was supported by a traveling frame running on pneumatic tires near the edge of the roof and anchored back into the skylight at the top. Steel cables and drums on the platform carrying the winding machine regulated the height of the machine. The reinforcing steel was a No. 8 steel wire which was drawn through a die reducing the diameter to a No. 10 wire, which process gave the required tension per sq. inch. In the lower half of the tanks two windings were made to get the required amount of steel. The first winding was covered with concrete followed by a second wiring and another layer of concrete. In the upper half, one winding only was made. The total number of turns of wire in the first foot above the base was 45, the number in each succeeding foot being reduced corresponding to the reduced pressure until at the top only 4 turns were used.

"After each 5 turns of wire were made these were secured by welding a holding piece to them so that any breakage of the wires above would not loosen the tension in the wire below the weld."

While the plans were in the earliest stages, it was found that the pipe line, a wooden-stave pipe some 20 years old, running from one of our auxiliary reservoirs was in such bad shape that little or no water was being delivered through it to the main lake. This was a 16-inch line, running through very rough and swampy terrain. Due to the fact that the ground was frozen and excavation very difficult, we cut holes

every 100 ft. about 20 ft. in length and cut away the top half of the wooden stave. A man then crawled through from one hole to the next and pulled a rope through after him. Then 12-inch cement-asbestos pipe was put into the opening and pulled into the wooden-stave line by a pair of horses. The next cement-asbestos pipe was made up to the first pipe and that pulled into the wooden-stave, and so on, until the cement-asbestos pipe reached the next opening. This process was repeated until the whole line of some 5,000 ft was completed. Careful measurements were made and it was found that the required clearance between the ends of the pipe inside the collar had been retained.

This work was completed during the winter and left the Department with the major project before it. The major project having been completed, the men of the Department were then confronted with the applying of the pressure to the mains.

Turning on the pressure on October 10, 1943, resulted in three breaks in the transmission main and two in the distribution mains.

From the backfill around the pipe at the point of these breaks, it was evident that these mains had been leaking slightly in three of the five breaks that shot up during this process. These breaks having been repaired within 36 hours, after consultation, it was decided to test the transmission mains at night in short sections. This was done at the rate of one test a week, in order to be easy on the men, as invariably we found one leak in each one of the tests until the weak points in the mains were eliminated. After one of the transmission mains had been tested and found to hold pressure in its entirety, this pressure was then applied to the high-service system, raising the pressure in that system only about eight to ten pounds, with no resulting leaks. We then took small sections of the city in the low-pressure areas and applied the higher pressure; thus a few blocks at a time added the pressure to the entire city. The second transmission main was then put on to the higher pressure, with the ironical result that this main had no leaks, although the other main had had some six or seven leaks.

We continued to have main breaks for about a year and a half, these breaks occurring mostly on Sundays and holidays. In fact, the men of the Department for nearly two years spent their holidays repairing broken mains. During this period, several interesting and amusing incidents occurred. On one occasion, after repairing a leak

around the pipe which had run very close to the foot of a ledge, a farmer from about a mile away threatened to sue the city, because of the fact that the brook that had run through his dooryard as long as he could remember, as man and boy, had ceased to flow after we repaired the main. We knew that the main had been leaking for a good many years, because the ledge, which was about 8-10 in. away from the pipe—and the pipe had been split the entire 12-ft length on the side—had a slot worn in it about 6″ wide and about 5″ deep. We did not know, however, that it had been leaking enough to cause a brook to be running through a man's dooryard. Incidentally, the farmer did not sue the city.

In another instance, we found a 20″ pipe that was split the entire length and was held together by two strap-iron bands, which were drawn up tightly enough to hold the 40-lb pressure prior to the raising of the pressure on the main.

In the course of the trouble-shooting of the higher pressure, another rather amusing incident happened about three o'clock one morning, as we were lowering the new piece of pipe into place on the 20-inch line. The men in the trench came scrambling out, saying that there was fire down there. I had the pipe drawn back up the side of the trench and then lowered into place again. To my amazement, sparks flew across the gap of some 4 or 5 in. on each end of the pipe. As nearly as I could determine, this was electricity that resulted from the grounding of the wiring system of the houses over the water mains. This occurred about a mile from the nearest house and about one-half mile from the town line on the transmission main.

The men were mostly old timers in the water-works game and became so efficient in repairing mains that they could repair anything up to a 24-inch break within 8 to 10 hours from the time that it was reported.

WATER-WORKS OPERATING EXPENSES UNDER POST-WAR CONDITIONS

BY FRANK A. MARSTON*

[*Read September 14, 1949.*]

SINCE the end of World War II in 1945 there have been increases in wage rates, the prices of materials have advanced, and the costs of construction and operation of water-works have risen rapidly. By 1947 many water-works officials had cause to worry about the greatly increased proportion of operating revenue required to pay operating expense.

Graphical evidences of the higher costs of construction are shown in Fig. 1 for the period 1939 to 1948.

The cast-iron pipe quotations are the annual average prices published in *Engineering News-Record* per net ton f.o.b., Boston, in carload lots for 6-in. to 24-in. B & S Class B pipe and heavier. From 1939 to 1948 the increase in annual average price was 88.3%.

The construction cost index is that published by *Engineering News-Record*, transformed to a basis of the 1939 average equals 100. The increase for the period was 95.7%.

The third line on the diagram represents the combined ENR construction and building cost indices, adjusted for estimated labor productivity and for contingencies. This line in some ways more nearly represents the increases in cost for general water-works construction, including building construction, than either of the other two lines. The increase thus shown for the period 1939 to 1948 was 146.2%.

A study has been made of annual operating expense, as compared with operating revenue, for nine private-owned and eight public-owned water-works in New England for the years 1939 to 1948, inclusive.

Fig. 2 shows graphically the effect of war and post-war conditions on the ratio between operating expense and operating revenue. War conditions resulted in substantial increases in the volume of business and revenue of the water-works, but not enough to offset the greater increases in operating expense.

*Partner, Metcalf & Eddy, 20 Providence Street, Boston 16, Mass.

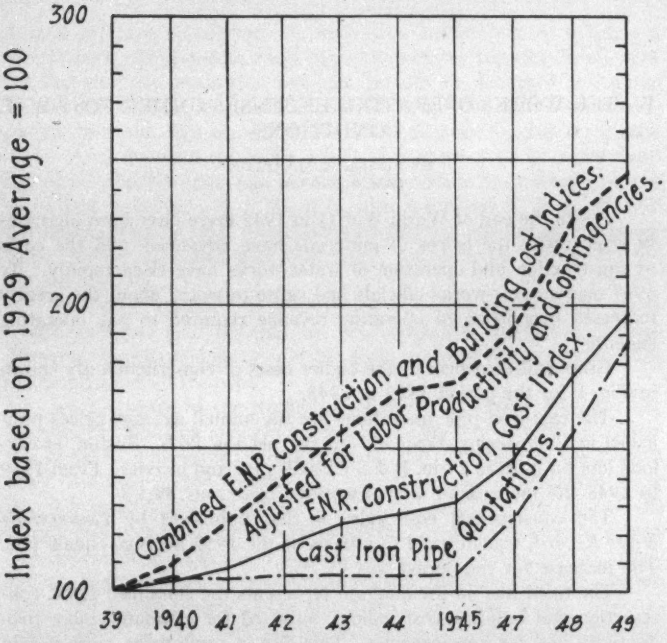


FIG. 1.—CONSTRUCTION COST INDICES AND CAST-IRON PIPE PRICES—YEARLY AVERAGES

The ratio of annual operating expense to revenue for the private-owned works increased from an average of 56.2% to 68.3% or more, and for the public-owned works from 31.8% to 49.2%.

For the purposes of this study, annual operating expense has been taken to include taxes but to exclude depreciation. Taxes, in general, have increased since the war began. For the nine private-owned companies, for which records were studied, the average proportions of the operating revenue spent for taxes from 1939 to 1948 are shown in Fig. 3. The record for one company in a city is shown also, to illustrate a case of heavy tax burden.

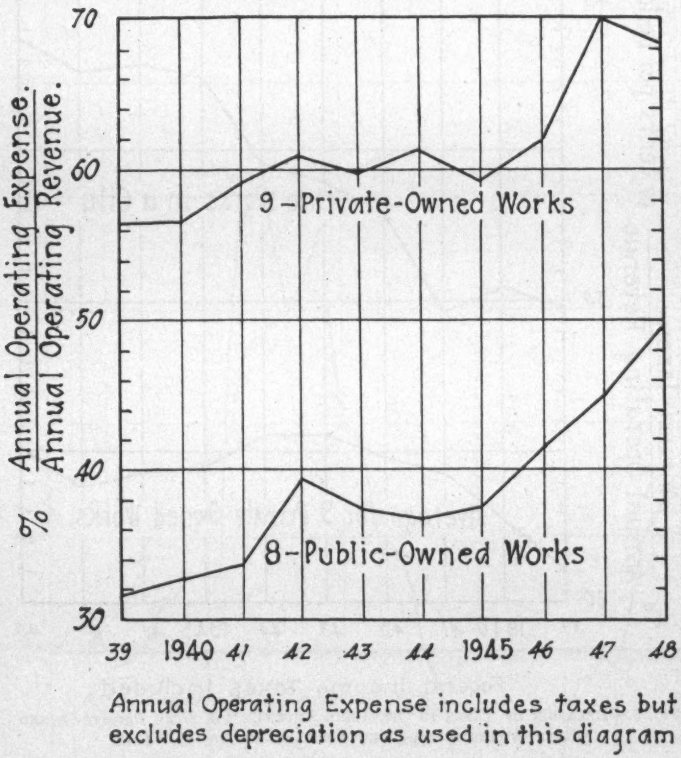


FIG. 2.—RELATION OF OPERATING EXPENSE TO OPERATING REVENUE FOR SOME WATER WORKS IN THE NEW ENGLAND STATES, 1939-1948.

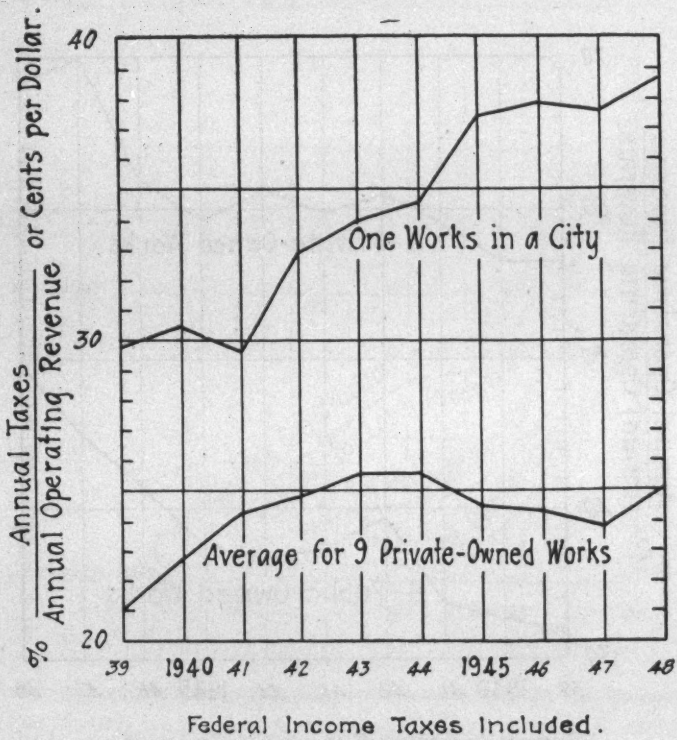


FIG. 3.—RELATION OF TAXES TO OPERATING REVENUE FOR SOME PRIVATE-OWNED WATER WORKS IN THE NEW ENGLAND STATES, 1939-1948.

In general, annual operating revenues of the nine companies studied increased considerably between 1939 and 1948, but the annual tax expense increased more rapidly, and particularly so during the war years of 1942 to 1944. In 1939 the average for the nine companies showed 21 cents out of the revenue dollar spent for taxes and

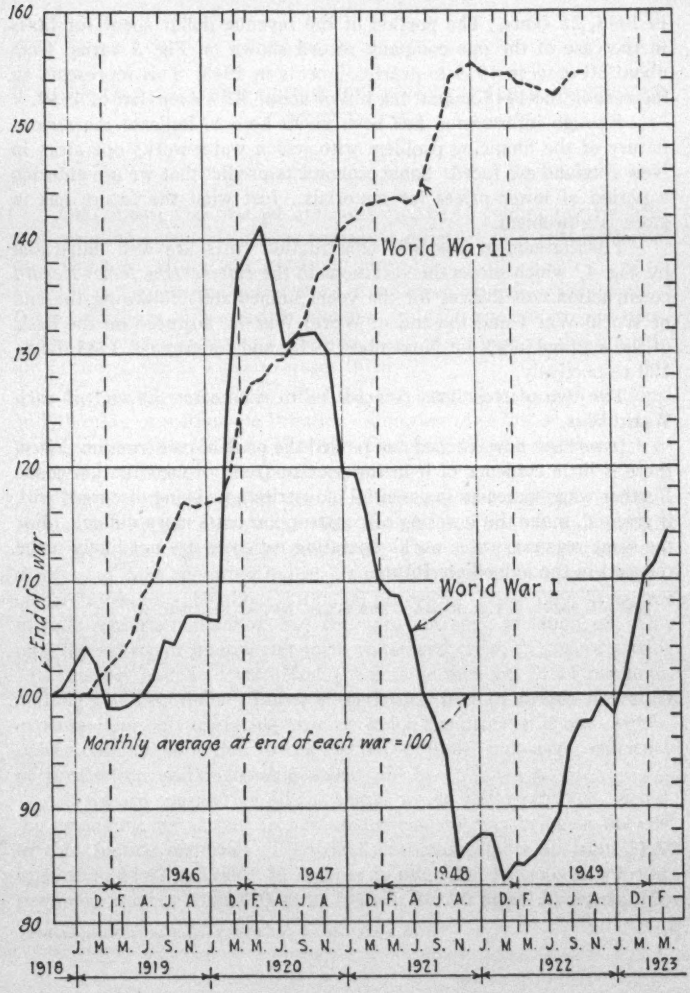


FIG. 4.—FLUCTUATIONS IN POST-WAR CONSTRUCTION COSTS, AS SHOWN BY E.N.R. CONSTRUCTION-COST INDICES.

in 1948, 25 cents. The portion of the revenue dollar spent for taxes in the case of the one company record shown on Fig. 3 varied from about 30 cents in 1939 to nearly 39 cents in 1948. This represents an increase in the 1948 annual tax bill of about 30% over that of 1939.

Enough information has been given here to indicate the serious nature of the financing problem with which water-works operators in New England are faced. Some economists predict that we are entering a period of lower prices for materials. Just what the future has in store is a problem.

Fluctuations in post-war construction costs are well illustrated by Fig. 4,[1] which shows the variations in the *Engineering News-Record* construction cost indices for the years immediately following the end of World War I and the end of World War II, adjusted on the basis of the average index for November, 1918, and for August, 1945, being 100 respectively.

The two plotted lines coincide as to time after the end of each World War.

If we have now reached and passed the peak of construction prices, there is little evidence of it in the present trend of construction costs. Further wage increases in essential industries now being discussed will, if granted, make the lowering of construction costs more difficult. For the same reasons, water-works operating expenses are not likely to be reduced in the immediate future.

---

[1]Similar to diagrams by L. R. Howson, J. AWWA, Sept., 1947, and Nov., 1948.

WATER-WORKS OPERATING EXPENSES UNDER POST-WAR CONDITIONS

BY PERCY A. SHAW*

[*Read September 14, 1949.*]

I HAVE assumed that we are not expected to confine our remarks to a mere statement of present operating expenses or a comparison of such expenses with those prevailing pre-war.

Let us begin with the last word in the given subject—"conditions." What conditions do we mean? Not the immediate post-war conditions, but those prevailing now, I presume; and also those in the immediate future, so far as we can foresee them.

The primary condition affecting the expense of our operations, and all other operations, is Inflation—inflation of prices or a reduction in the value of our dollar. The fifty-cent dollar is the direct cause of nearly all our operating-expense troubles.

Is this fifty-cent dollar just a phrase or is it a reality? At Manchester our weekly payroll has risen from $1,815 in 1940 to $3,824 in 1949, with the same number employed. This is a 110% increase and shows a 47-cent operating dollar. It also shows a $2,000-per-week increase in payrolls, or about $100,000 per year. These payroll figures include construction labor, but they are not easy to laugh off. Our pipe layers, repair men, meter men, watershed crew, etc., were getting 51 cents per hour in 1940. Now these same men get $1.11 per hour, making a 46-cent dollar. Labor is the largest item of strictly operating expense. Our only operating expense which has dropped is our electric-power cost. This is due to the electric utilities' increasing efficiency of production and increasing sales.

If we are considering all the things we do as "operating", including extending our service to new customers, we may bring in the cost of construction materials. Eight-inch cast-iron pipe is up from $1.37 in 1940 to $2.47 in 1949; ¾" copper tubing from 16 cents to 29 cents per foot; meters from $10.40 in 1940 to $17.00 now; hydrants from

*Superintendent and Engineer, Water Works, Manchester, N. H.

$80. to $130., and nearly everything else is in proportion. I think we may conclude that the 50¢ dollar is here all right.

Will it stay? Howson shows that after other wars construction costs have settled down at about 50% above pre-war. Labor is so strongly entrenched now and has such important political backing, that I do not expect that prices will go down from double to one and a half times pre-war for at least several years.

But I do not need to tell you that expenses have gone up. Why are we talking about them? Surely, in the hope that we can do something about them—and that something is to reduce them. And if we can't reduce them—then to find ways and means to pay them.

How reduce them? As we consider the strictly operating budget, two words come to mind: "efficiency" and "equipment", the latter signifying machines.

Efficiency results from careful planning, organization and supervision on the part of the top men in your organization—applying the old idea of making your head save several pairs of heels. First know your costs. Compare costs of different jobs; compare this month's operations with last month's. Check over your buying habits.

We have been scheduling all work ahead. On main-extension and service jobs, which are numerous this year, this means economy in moving men and equipment. For our watershed maintenance, forestry work and pumping-station maintenance, many of the operations are repeated month after month, or year after year. With these we have regular schedules worked up on large sheets of profile paper, showing the jobs to be done and the time of year or month to do them. For emergency jobs we use a system of slips, on which the job is described, with a space for a report on completion. This pre-thinking saves time and expense.

For additional savings we can follow the trend in this country and use more machinery of every kind, in the office and outside. Not only has your worker's pay increased, but he is (with us anyway) unwilling to do heavy continuous work, like pick-and-shovel excavation of trenches. Your pipe materials may cost you twice as much as pre-war, but your excavating should cost you little, if any, more.

I hardly think, however, that any of us have been doing such a sloppy job that we can compensate for the 50¢ dollar by more efficient

operating. I think you will have to find more income. There is no sound reason why you should not increase the charge for your service —nearly everyone else has. Howson in his analysis of conditions in the American Water Works Association Journal concludes that, on the average, the water-works industry will have to raise rates at least 30%.

We raised our regular water rate at Manchester 20%; the almost complete lack of criticism was surprising and gratifying. We set out to obtain a further increase in our income by making a charge for private fire-protection service. This charge approximated $5. per year per square inch of connection to our mains. What a difference! What a howl! Our manufacturers and big building owners had never paid for the private fire protection they receive and did not intend to. We reduced the charge to $3. per square inch of connection in an attempt to compromise—still vigorous objection and finally a law suit. Now they are paying on the $3. basis by Court order and they are going to Court to find out whether we can keep the money or not.

If your hide is thick and your nerves steady, or if you are a super-salesman, try the same method of raising income. You will have my sympathy.

If we include the expansion of our systems under operating expense, which of course it is not, cheap money will help you at least to spread the cost of delayed expansion over a period of years. Money can be hired, if your credit is good, for little more than half of what you would have paid pre-war. It is the only thing that is cheap—but you have to pay it back. Whether you will be able to pay it back in cheap dollars is a question.

We have extended our system in the past as much out of income as possible. We do not owe a cent on our property now and hope to avoid borrowing. But I sometimes wonder if we are wise in not taking advantage of the prevailing, very low borrowing rates.

An indirect result of high prices, high wages and comparatively low water rates is that we find people in general using more water. Since the water bill is a small item, compared with other expenses, water is used freely in the house and on lawns. This increases income and helps to meet expenses. Our income increased from $248,000 in 1940 to $328,000 in 1947; in 1948 an income of $409,000 reflected little more than our 20% increase in rates. The increase in water sales

during the summer months and increased industrial use have materially increased our income, helping us to pay the expenses which we have only partly licked by efficiency and machinery.

Efficiency—Economy—Machinery
Planning—Organization—Supervision

Is there anything new in those ideas?

No! Not a thing!

Good Product—Fair Prices—Hard Work

As Noah said to the Donkey when he landed on Ararat:—
"It's the same old World!"

WATER-WORKS OPERATING EXPENSES UNDER POST-WAR CONDITIONS

BY THEODORE L. BRISTOL*

[*Read September 14, 1949.*]

SOME time ago Truman H. Safford, Chairman of the Technical Program Committee, asked me to participate in the discussion of higher operating costs from the viewpoint of one of the smaller private companies whose rates are subject to regulation. In response, here are some of the things I have brought to light from the records of the Ansonia Water Co. of Ansonia, Conn.:

COMPARISON OF WAGES AND SALARIES, 1940-1949

	1940	*1949*	*Increase*
1.	$ 7,200	$ 8,000	$ 800
2.	3,650	3,700[1]	50
3.	2,700	5,600	2,900
4.	1,492	4,700	3,208
5.	1,696	2,960	1,264
6.	1,158	3,757	2,599
7.	1,274	2,681	1,407
8.	1,040	2,442	1,402
9.	1,225	2,561	1,336
10.	1,526	3,040	1,514
Total	$22,961	$39,441	$16,480

[1]Part time.

These figures are based on a 44-hour week, with time and a half for more than 40 hours. The above does not cover all our employees —only those working in both these years.

*President, Ansonia Water Co., 354 Main Street, Ansonia, Conn.

	1940	*1948*	*Increase*
Municipal taxes on land	$ 5,506.78	$10,141.13	$4,634.35
Federal income tax	16,718.07	18,901.34	2,183.27
State franchise tax	1,998.16	2,315.93	317.77
Social security tax	240.85	424.88	184.03

	1939	*1948*	*Increase*
Telephone cost	$249.64	$401.42	$151.78

COST OF MATERIALS

	1940	*1949*	*Increase*
1" copper tubing—per foot	$0.165	$0.366	$0.201
Hydrotite—per pound	0.10	0.11	0.01
Transite pipe— 8"—per foot	0.965	1.73	0.765
6"—per foot	0.685	1.20	0.515
Cast-iron pipe, cement-lined—8"—per foot	1.22	2.15	0.93
6"—per foot	0.85	1.50	0.65
Fence posts—7½'—each	0.58	1.00	0.42
Barbed wire—80-rod coil	3.44	6.99	3.55
Water analysis—per sample	4.00	6.00	2.00
Bituminous-mix stone—per ton	4.18	6.10	1.82
Chlorine—per pound	0.075	0.105	0.03
Meters—⅝" × ¾"— cast-iron bottom—each	10.00	17.50	7.50

	1940	*1948*	*Increase*	*Decrease*
Gross Revenue	$131,483	$143,298	$11,815	
Operating Expenses	73,705	110,288	36,583	
Net Operating Income	$ 57,778	$ 33,010		$ 24,768.

Gross Revenue for 1949, based on first six months	$147,320
Expense for 1949, based on first six months	120,470.
Net Revenue for 1949, based on first six months	$ 26,850

as compared with $33,010 for 1948.

WATER-WORKS OPERATING EXPENSES UNDER POST-WAR CONDITIONS

BY EDWIN T. McDOWELL*

[*Read September 14, 1949.*]

FOR the past two or three years the subject that probably has been uppermost in the mind of the average water-works official—the matter that has given him the greatest concern—has been the alarming and unprecedented upward trend in the operating expenses of his organization. Regulated on one hand as to the price he may charge for his product and forced on the other hand by rapidly changing economic conditions to grant successive wage increases to his employees and to pay ever higher prices for the materials and services that enter into the acquisition and processing of his product, he has been squeezed into a very uncomfortable position.

It was not long after the cessation of hostilities in Europe and the Pacific that the Public Utilities Commission of Maine was made aware that all was not well with the utility boys. The first to appeal to the Commission for relief were the gas utilities. The reason for this is not far to seek; the principal ingredients consumed in the manufacture of gas are coal and oil, and the cost of these materials exerts a direct and immediate influence upon the production cost of gas. Since all of us can remember what happened to our own fuel bills during and immediately following the war, it is easy to visualize the predicament in which the gas producers soon found themselves. With one exception, every gas utility in the State has petitioned at least once since the war for an adjustment of consumer rates and some have appealed to the Commission more than once. All were granted increases.

Among the water utilities the first to appeal to the Commission were the privately owned companies. I assume that the reason for this is that the corporate form of management is perhaps a little more flexible and is able to act a little more promptly in matters of this kind. It also is undeterred by local political considerations, which sometimes

*Engineer, Maine Public Utilities Commission, Augusta, Maine.

make the publicly owned utility reluctant to ask for higher rates, which must be paid from the purses of its friends and neighbors. As time went on, however, the publicly owned utilities also began to feel the pressure of rising costs and I believe they understood that the consumer public had come to a realization that increases in water rates were in most instances inevitable. Petitions for rate adjustments began to trickle into the Commission's office.

The trickle which began in 1946 grew apace and, before the end of 1948, it had assumed the proportions of a flood. In the great majority of cases it was quickly apparent that relief was needed and many rate schedules were adjusted upward, although not necessarily in the amount or form requested. A few petitions were denied for various reasons, some were revised downward and in one case the upshot of the utility's petition was an order from the Commission to reduce rates in certain classifications.

During the past two years the staff of the Public Utilities Commission has had occasion to study the financial set-up and operating results of many water utilities and, for the purpose of the present survey, I have tabulated the operating results of several water-utility corporations and water districts. I have included both water companies and water districts because of the differences in their organization and objectives, which have a considerable bearing upon operating results and financial structure. There are very few municipally operated water departments in Maine and a study of their operations is not included. For our immediate purpose I have selected several water companies and water districts which have the resources and skilled personnel to compile accurate and detailed records. Sources of information were the regular annual reports, as filed with the Public Utilities Commission, and personal contact with officials of the utilities themselves.

I have compared the operating results of 1939, the last year before the outbreak of war, and the year 1948, which is the last full year for which reports are available. Without delving too deeply into masses of figures which are always tiresome and soon forgotten—I have many of them here if you wish to consult them—I shall mention a few that I believe serve to illustrate the problem now facing many of the water-utility operators.

During the period under consideration the expenses of the water utilities which were studied have increased on an average as follows:

	Water companies			Water districts		
	1939	1948	Ave. increase	1939	1948	Ave. increase
Operation and maintenance			55%			78%
Taxes			102%			——
Depreciation			23%			38%
Income deductions			21%			13%
Total operating expenses			57%			61%
Ratio: Operation & Maint. to Operating Revenue	29%	33%	15%	30%	43%	44%
Ratio: Total Operating Exp. to Operating Rev.	56%	65%	16%	48%	64%	33%

It will be noted that the greatest increases have occurred in operation and maintenance accounts and in taxes.

If the Operation and Maintenance expenses are broken down into some of their subdivisions, the reports reflect the following increases from 1939 to 1948:

	Water companies	Water districts
Purification—Operation	125%	161%
Pumping— "	49%	99%
Distribution— "	48%	89%
Purification—Maintenance	18%	327%
Pumping— "	0	126%
Distribution— "	84%	98%
Customer Accounting and Collecting	57%	46%
General and Miscel. Expense	25%	89%

The greatly increased cost of pumping and purification is partly due to rising prices of fuel and purification materials and, in some cases, electric power. The greatest factor, however, is higher wages and increased personnel. Operating crews no longer work the long hours of the pre-war years and in many plants additional crews are required. When an old operator dies or is retired, it is often necessary

to secure two men—and at a higher wage scale—to replace the old fellow.

The same holds true for the increase in distribution and office expenses. The trend toward higher wages and a shorter work-week has been unmistakable and unavoidable. The effects of gains that unionized labor has wrung from the larger industries sooner or later filter down to the smaller enterprises, including the utilities. In order to secure competent employees, the water utilities have been obliged to conform to this trend.

The recent costs for maintenance are probably not truly representative of what may be expected in the near future. During the war all but the most vital and necessary maintenance work was deferred. An enormous back-log was accumulated, which the average water superintendent set about reducing as soon as labor and materials again became available. A tremendous amount of this work has been going on and presumably will continue for the immediate future. Standpipes and tanks need painting; filtration and pumping equipment needs overhauling; buildings need repairs; in fact, there are hundreds of maintenance jobs which were put off and the process of catching-up goes on apace. It is not to be expected that maintenance costs will return to pre-war stature, but in time most of the deferred projects will reach completion and maintenance work should more nearly approach former volume.

Few people realize how much they are paying in the form of hidden taxes, which are collected through the medium of consumer bills for various utility services. For water districts and municipal water departments, the tax bill is usually small and relatively unimportant, but in the case of water companies it constitutes one of the major items of expense. The sad part is that the more efficiently a plant is operated, the higher the tax bill becomes and, if the operator is so fortunate as to make a profit and present his stockholders with a dividend, the federal income-tax collector steps in and extracts an additional slice from the individuals to whom the dividend is paid. The tax bill of the average water company has increased 100%, or more, in the period from 1939 to 1948. In 1939 taxes accounted for 31% of total operating expenses and 18¢ of the rate-payer's dollar. In 1948 taxes were 37% of total expenses and absorbed 24¢ of the

consumer's dollar. As to the future trend in taxes, only the Congress and the local boards of assessors can give an answer, and I certainly would not have the temerity to predict what that answer would be.

It might be interesting to know how your rate-payer's dollar is spent by the average water utility:

	Water companies		Water districts	
	1939	1948	1939	1948
Operation and Maintenance	$0.29	$0.33	$0.30	$0.42
Taxes	0.18	0.24	—	—
Depreciation	0.09	0.08	0.18	0.19
Income Deductions	0.21	0.15	0.44	0.35
Net Income	0.23	0.20	0.08	0.04
	$1.00	$1.00	$1.00	$1.00

It will be observed that in both instances the proportion absorbed by income deductions has decreased. This is one of the bright spots in the picture. Most public utilities have taken advantage of declining interest rates to refund their callable bonds with new ones of lower coupon and some have actually issued new bonds at very low interest rates and invested the proceeds in other outside bonds of higher coupon, to provide a very welcome source of income. These securities and the income therefrom are placed in the sinking fund against the day when their own bonds reach maturity. It is probable that interest rates will remain low for the foreseeable future. With its eye upon the huge public debt, the federal government certainly will vigorously oppose any attempt to return interest rates for long-term borrowing to their former levels.

Following are the average rates paid for money on a long-term basis in 1939 as compared with 1948:

	Water companies			Water districts		
	1939	1948	Decrease in cost	1939	1948	Decrease in cost
Interest Rates	4.63%	3.25%	27.65%	3.77%	2.92%	22.18%

The increases in total costs have certainly been alarming to the water-works officials but, while this has been going on, most of the utilities have enjoyed a very healthy expansion in business and revenue, if not in net income. The figures show that people are using and paying for more water; new customers have come on existing pipe lines, with a consequent increase in revenue, but with small additional investment in distribution mains and other facilities. Therefore costs, as measured by such units as "per gallon of output", "per customer", "per dollar of revenue", etc., have not risen in the same proportion as total costs. In the same manner investment in operating property, measured by the same units, has lagged behind and, in some instances, actually decreased. The following table will serve to illustrate this.

PERCENTAGE INCREASE OR (DECREASE), 1939-1948

	Water companies	Water districts
Number of Services	15.7	15.0
Water Mains, feet	4.9	9.9
Yearly Output, gallons	27.9	28.6
Depreciation Reserve	89.0	95.6
Investment, total	14.20	16.81
" per service	(1.07)	3.03
" " ft. of mains	8.71	6.45
" " gallon output	(5.91)	(7.90)
" " dollar of revenue	(14.81)	(2.60)
Operating Revenue, total	34.46	22.19
" " per service	16.22	8.98
" " " ft. of mains	27.91	12.75
" " " gal. output	10.19	0.25
Operating Expense, total	57.08	61.00
" " per service	35.98	41.88
" " " ft. of mains	49.34	46.93
" " " gal. output	28.51	27.31
" " " dollar of revenue	16.55	30.47

The percentage of increase in revenue has been greater than that of investment or output, and the utilities have apparently done a good job of building up reserves, which should put them in a favorable

position when the time comes for replacing or abandoning portions of their present property and equipment.

In all probability adequate reserves and much additional financing will soon be needed. From correspondence received at the office and from personal contact with many water-works superintendents throughout the State of Maine, it has become apparent that many water utilities will soon be faced with the necessity of expanding and replacing present facilities. Sources of supply are becoming inadequate or unsuitable; pumps and filtration equipment are wearing out or becoming outmoded; transmission mains are overloaded, and storage tanks must be added. In addition to these, there is an insistent and growing demand for the extension of distribution systems into new territory, to serve existing homes and new ones about to be built. Some utilities are already in the process of accomplishing these objectives and others are in the blueprint stage. Such changes will call for heavy expenditures of capital, which in many instances will bring in little additional revenue but will undoubtedly result in improved operating efficiency. The problems of financing these expenditures and of devising adequate and equitable rates to support the additional property investment and expanded operations will require a great deal of careful study and good judgment on the part of both water-works officials and utility commissions for some time to come.

IRON AND MANGANESE REMOVAL IN THE SPAULDING PRECIPITATOR

BY R. H. BABCOCK*

[*Read September 15, 1949.*]

SYNOPSIS

THE removal of iron and manganese from ground waters has always been a difficult task. This paper describes and analyzes pilot-plant experiments made at the city of Lowell, Mass., using the Spaulding precipitator for the removal of iron and manganese. The pilot-plant results are compared with jar tests made on the same water and the efficiency of the upward-flow-type tank is demonstrated on an experimental basis.

INTRODUCTION

The pilot-plant at the Boulevard well field at Lowell, Mass., was built to test the efficiency of the Spaulding precipitator and sludge blanket for the removal of iron and manganese from the water. This piece of equipment embodies the principle of a sludge blanket which is suspended in a tank by the velocity of the influent and acts both as a filter and a catalytic surface for future chemical to react with, forming more blanket. Investigation indicates that this pilot-plant was the first to be built using the Spaulding precipitator for the removal of manganese. The complete plant also included an aerator and slow sand filter.

PLANT DESCRIPTION

Fig. 1 is a schematic diagram of the pilot-plant. A tap was made in the influent main of the present treatment plant and the raw water was allowed to flow into a 55-gal drum, which had a small domestic sump pump in the bottom. The flow from the main was adjusted so that at lowest operating pressure the drum just overflowed. This arrangement eliminated the difficulties that would be caused by varying

*Engineer, Interstate Sanitation Commission, New York, N. Y.; formerly Sanitary Engineer, Whitman & Howard, Boston, Mass.

quantities of flow through the pilot-plant. The raw water was pumped through the aerator and drained into a sump, which contained a second sump pump. It will be noted that a by-pass is provided, so that raw water can be sent directly to the precipitator without being aerated. Before the water entered the precipitator, it passed through a disk-type meter, which activated the chemical feeds.

The precipitator-treated water was pumped to the slow sand filter. The filter was an exact replica, with respect to material and depths, of the existing slow sand filters. The filter being 2½ ft in diameter, it was allowed to pass only a small quantity of water, to obtain the proper flow for its surface area. The remainder of the water going on to the filter was allowed to go to waste by the overflow pipe. Sampling taps were located so that samples could be taken at every stage of the treatment.

The water to be treated entered the precipitator at the top of the central section, after first being mixed with the chemicals which were used for coagulation. It passed downward into the mixing zone, making contact with previously formed sludge, which was circulated in the central section of the precipitator by the agitators. This contact with existing sludge produced a floc almost instantly at dosages that require measurable time to floc in jar tests. The coagulated water then passed out of the central section to the outer sections where, due to the cross-sectional shape, the velocity of the rising water reached the velocity of the settling floc. It was at this point that the sludge blanket was formed. Above this point the clear-water zone existed. The treated water passed into collector flumes and out of the precipitator.

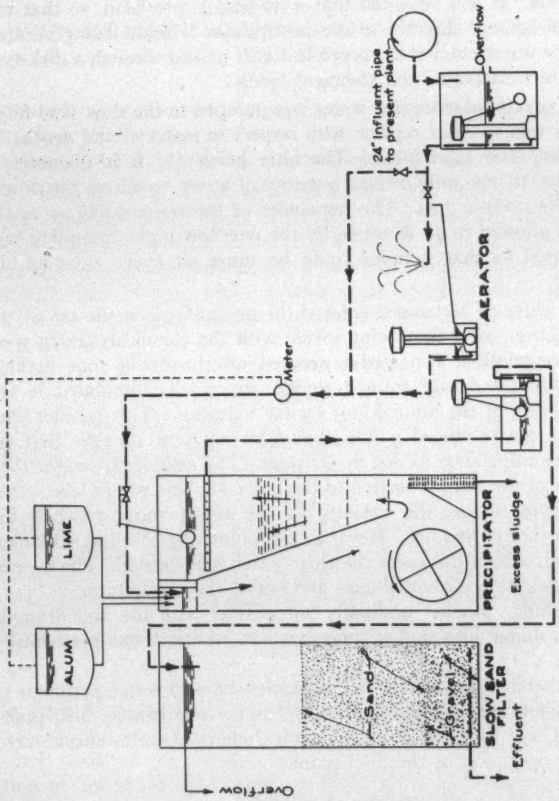
The sludge blanket gradually got heavier with use and dropped part of its sludge into sludge concentrators, where it was periodically drawn off.

The chemical characteristics of Boulevard well water pertinent to this discussion are as follows: iron, 4.4 ppm; manganese, 0.80 ppm; pH, 6.3. These were the general chemical characteristics encountered during the operation of the pilot-plant.

Plant Operation

The chemicals used were alum and lime.

The plant operation was divided into three sections:



SCHEMATIC DIAGRAM OF PILOT PLANT

Figure 1

(A) Investigation and experimentation, to determine the best method and the chemical dosage to develop the nucleus of a sludge blanket in the shortest time.

(B) Experimentation involving the use of the whole—that is, aeration, chemical precipitation and filtration—the chemical precipitation being done in the precipitator.

(C) Experimentation involving the use of a portion of the plant —that is, chemical precipitation and filtration—the chemical precipitation again being done in the precipitator. Aeration was omitted, to observe the effect on iron and manganese removal in the precipitator.

Investigation as to the fastest method of forming a sludge-blanket nucleus was begun by putting the plant in operation and feeding high dosages of alum and lime (7 grains per gal of each). This was continued for some time without any indication of a blanket's forming. There being no blanket originally, the floc passed out of the tank and on to the filter. It was concluded that some bed must exist, in order to put a precipitator in operation and have any removals take place within a reasonable time.

The adding of a slug of chemical without the precipitator in operation was tried next. From jar tests it was found that 15 grains per gal (gpg) of alum and 8 gpg of lime gave a heavy floc. The precipitator tank was filled half-way and the lime added. The agitators were set in rapid motion for five minutes and the alum was added. The agitators were then slowed and the tank completely filled. The full tank was slowly agitated for one hour and then set in operation, 7 gpg of alum and 7 gpg of lime being fed. It took about six hours of operation to get a blanket that was functioning efficiently. Various timings and bulk dosages were tried. It was found that 22 gpg of alum and 22 gpg of lime, added to one-half tank of water, agitated rapidly for five minutes and slowly for one hour, while the tank filled, gave the best results. Within two to three hours after the plant was set in operation the sludge blanket was operating efficiently. Full efficiency was not obtained for at least 12 hours, regardless of the method of initial blanket development used.

The portion of the work to which most of the time was devoted was the testing of the plant effluents, to determine the efficiency of iron

and manganese removal. This was first tried with aeration, chemical precipitation in the precipitator, and slow sand filtration. The chemical dosages were started at 7.3 gpg of alum and 7 gpg of lime, with the plant operating at 5 gal per min.

These dosages were gradually reduced to 2.5 gpg of alum and 2.5 gpg of lime. From Table 1 it can be seen that the greatest changes that occurred were those of pH. While the iron and manganese left in the water after precipitation increased slightly as the chemical dosages decreased, the increase was negligible compared with the chemical savings incurred.

The next series of experiments was run with chemical precipitation in the precipitator and slow sand filtration, aeration being eliminated. Again the chemical dosages were started high (alum, 3.4 gpg; lime, 3.5 gpg) and gradually reduced to 2.5 gpg of alum and 3 gpg of lime.

From Table 1 it can be seen that the low dosages in both series of experiments gave about the same results. In both cases, when the dosages were taken below the low figures herein mentioned, the sludge blanket broke down and passed on to the filter.

Fig. 2 shows a relation between pH and iron and manganese residuals before filtration that is of interest. It indicates the importance of pH as related to iron and manganese removals experienced. It bears out the opinion of Moore and Snow[1] that pH control is of prime importance in a process of this type. In general, it was found that the optimum pH zone was 8.5 to 9.1.

The form in which the residual iron and manganese occurred in the precipitator effluent is believed to be in the small amount of floc which always passes on to the filter. This can be observed in Table 1, by comparing precipitator effluents which were sand filtered with those which were passed through filter paper. The results with respect to iron and manganese were the same.

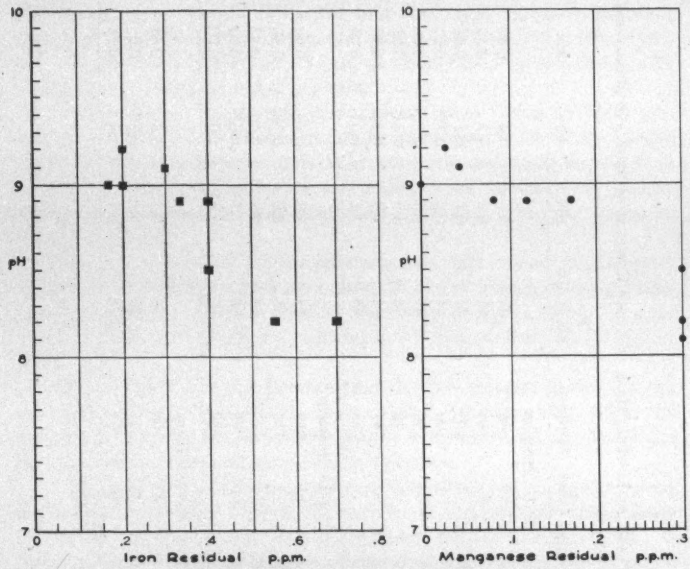
The observation that the residual iron and manganese is tied up in the small amount of escaping floc leads one to conclude that the pH of the effluent is a measure of the sludge-blanket stability, as practically all of the iron and manganese could be removed by passing the precipitator effluent through filter paper; hence, most of the iron and

[1] "Studies on the Removal of Iron and Manganese from Water", by E. W. Moore and E. A. Snow. This JOURNAL, Sept., 1942.

TABLE 1.—SUMMARY OF RESULTS OF PILOT PLANT AT LOWELL, MASS., FOR THE REMOVAL OF IRON AND MANGANESE

Source	Alum (gpg)	Lime (gpg)	Turbidity	Color	Hardness	Total alkalinity	pH	Fe	Mn
				With Aeration					
Raw			1	60	48	41	6.3	4.4	0.80
Aerated			1	80	44	41	6.8	4.2	0.50
Precipitated	7.3	7	10	2	120	53	9.2	0.2	0.025
Precipitated	4	5	7	2	90	44	9.0	0.17	0.00
Precipitated	2.8	3.5	7	2	90	46	9.0	0.2	0.00
Precipitated	2.5	2.5	7	8	91	46	8.9	0.33	0.08
Filtered (Sand)			0	0	84	45	7.0	0.02	0.00
Filtered (Paper)			0	0	85	45	7.1	0.02	0.00
				Without Aeration					
Precipitated	3.40	3.55	8	15	110	58	8.5	0.40	0.30
Precipitated	2.60	3.0	12	15	110	58	8.2	0.70	0.30
Precipitated	2.5	3.0	8	15	110	58	8.9	0.40	0.12
Filtered (Sand)			0	0	97	60	7.1	0.02	0.00
Filtered (Paper)			0	0	99	60	7.1	0.02	0.00
				Present Plant					
Coke Filters			1	45	60	38	6.7	3.8	0.60
Sand Filters			0	25	44	27	6.2	0.70	0.0
City Mains			0	40	44	38	6.4	1.4	0.15

NOTE: All quantities in ppm, unless otherwise noted.



IRON AND MANGANESE RESIDUALS
AFTER PRECIPITATION

Figure 2

manganese in the raw water must be tied up in the coagulated mass which constitutes the sludge blanket.

The floc was observed to settle on the top of the filter and not penetrate as will iron from aerated water. This makes for ease of cleaning and eliminates plugged filters due to the formation of iron compounds in the lower portions of the filter.

The total removal of iron averaged 95% and that of manganese averaged 99%. This is considerably in excess of the present removal experienced at Lowell, of 68% for iron and 96% for manganese, for that water which passes through the entire plant.

The present plant effluent at Lowell has 84% of the iron and

100% of the manganese removed. The difference in figures is accounted for by the fact that the present sand filters are so badly plugged that a portion of the water is by-passed directly to the city.

It will be observed from the table of results that the total hardness of the pilot-plant effluent as compared with the raw water was double, the raw water having a total hardness of about 50 ppm and the pilot-plant effluent having a hardness in the neighborhood of 100 ppm. This hardness is excessive for New England although not for many parts of the country. The use of lime as an alkaline material was the cause of the increased hardness. By using soda ash, or soda ash and lime in various proportions, water of any desired hardness from 50 ppm to 100 ppm could be produced. The use of a mixture of soda ash and lime was tried at the pilot-plant and produced an acceptable sludge blanket.

The depth of the precipitator at the pilot-plant was 9 ft. Any final installation would have a depth of 12 ft., giving 33% more depth for the water to rise through than was available at the pilot-plant. This excess depth will result in the removal of smaller particles and, consequently, not so stable a sludge blanket will be required in a final installation as was needed at the pilot-plant. As the pH was the indicator of sludge-blanket stability, it will probably be possible in a final installation to reduce the quantity of alkaline material fed to the influent and hence the hardness, if lime is used as an alkaline material.

A series of jar tests was made on water from this same source at the Lawrence Experiment Station of the Massachusetts Department of Public Health by Joseph A. McCarthy, Chief Chemist, and the author. The object was to determine whether conventional chemical precipitation would give as satisfactory results as the precipitator used at the pilot-plant. It can be seen from Table 2 that the chemical analysis of the raw water at the time of the jar tests was quite different from that of the water treated at the pilot plant.

The removals experienced during these jar tests were quite unsatisfactory and did not compare with those of the pilot-plant precipitator, the lowest residual experienced during the jar tests being 0.40 ppm of iron and 0.49 ppm of manganese, as compared with 0.17 ppm of iron and 0.00 ppm of manganese from the pilot-plant precipitator.

While the pilot plant was in the planning stage, the author made

TABLE 2.—SUMMARY OF JAR TESTS

By Babcock and Turcotte	Fe	Mn	pH
Blvd. raw water	4.4	0.80	6.5
1 gr/gal alum, settled	4.0	0.80	6.3
3 gr/gal alum 3.5 gr/gal soda ash, settled	1.6	0.70	6.7
2.5 gr/gal alum, 2.5 gr/gal lime, settled	0.40	0.60	6.7

By Babcock and McCarthy	Fe	Mn	pH
Blvd. raw water	6.8	1.0	6.5
2.0 gr/gal alum, 1.0 gr/gal lime, settled	0.75	0.70	6.5
1.5 gr/gal alum, 2.5 gr/gal lime, settled	2.0	0.49	7.5
2.0 gr/gal alum, 3.0 gr/gal lime, settled	0.84	0.49	7.6
2.5 gr/gal alum, 3.0 gr/gal lime, settled	1.0	0.49	7.5
2.0 gr/gal alum, 2.0 gr/gal lime, settled	1.1	0.84	7.2

some jar tests on Boulevard well water with the assistance of David Turcotte, Plant Chemist. From Table 2 it can be seen that the iron and manganese content of the raw water was similar to that of the water treated by the pilot plant.

In both series of jar tests, the samples being tested were settled two hours.

Summary and Conclusions

The work done at this pilot plant indicates that the Spaulding precipitator efficiently removes iron and manganese. The following conclusions may be drawn from this work:

(1) The use of the precipitator relieves the sand filters of the tremendous load of work they carry in iron-removal plants of the aeration, sedimentation and filtration type. Approximately 95% of the iron and manganese is removed by the precipitator when proper pH is maintained.

(2) The iron and manganese which remains in the precipitator effluent is tied up with the small amount of floc which passes through the precipitator. This floc is removed on the filter surface and does not penetrate, as do the iron compounds which result from aeration. The result of this is that the frequency of filter cleaning will be considerably reduced.

(3) The control of pH is very important, the optimum zone of operation being between pH 8.5 and pH 9.1 for the water tested.

(4) The chemical savings resulting from the use of the precipitator are very large, as compared with conventional dosing and settling.

(5) Because the detention period of a precipitator is from 1 to 1.5 hours, the cost of construction of the smaller tank, as compared with conventional settling basins, will be much less.

(6) Comparisons between the pilot-plant results and jar tests show that conventional chemical precipitation was much less efficient for iron and manganese removal than was the precipitator.

Acknowledgments

The author wishes to acknowledge the assistance of Mr. David Turcotte, Chemist, Lowell Water Department, Mr. Joseph McCarthy, Chief Chemist, Lawrence Experiment Station, Massachusetts Department of Public Health, and Mr. Durando Miller, of the Permutit Co., New York.

MUTUAL INTERESTS BETWEEN THE WATER-WORKS AND ATOMIC-ENERGY INDUSTRIES

BY ARTHUR E. GORMAN*

[*Read September 15, 1949.*]

IT HAS become almost axiomatic that the water-works industry has a common and continuing interest in the development of new industrial enterprises and, conversely, that most new industries are dependent on adequate water service for domestic and process uses. But when a new industry such as the atomic-energy industry is developed, with its prolific potentialities for constructive and destructive applications and with its operations and destinies controlled by the federal government, it becomes a matter of profound interest and significance to all who are concerned with the growth and welfare of the two industries. The purpose of this paper is to discuss some of the majori items of joint interest between the two industries, especially from the point of view of water-works operation.

It is wholly understandable that any water-works official, whether his responsibility involves management, expansion, operation or control functions, should want to know how and to what extent his utility is likely to be affected by a new industrial development. His experiences of the past with new industries had led him to be concerned over such basic items of planning and operation as: the load he must meet in rendering adequate service; the effect of peak demands on supply to other consumers; the possibility of cross-connections between piping in his system and that of the new industrial water systems; the necessity for system reinforcement to meet fire hazards, and the requirements of additional housing for employees or the possibility that industrial wastes will contaminate his source of supply. But these are more or less orthodox items of interest and concern.

ATOMIC-ENERGY INDUSTRY UNIQUE

In dealing with the atomic-energy industry there are other factors which call for some marked reorientation of our normal concept and

*Sanitary Engineer, U. S. Atomic Energy Commission, 138 A. E. C. Bldg., Washington, D. C.

practices. We are working with an industry whose raw products are rare and costly; whose processes are unique and require special facilities and unusual technical supervision; whose finished products and wastes can be extremely hazardous, some of which have a life expectancy beyond the concept of man; and, finally, an industry whose useful and destructive possibilities are yet immeasurable.

To date, the impact of this new industry on the long established and well organized water-works industry has been slight. But its possibilities are great and they can be of a positive and constructive nature. This, in turn, will depend largely on the initiative and interest which the water-works profession takes in the various service and research programs of the atomic-energy industry, the degree to which its experienced technicians give of their services to help the atomic-energy industry in its developmental era, and the extent to which its young recruits are willing to devote themselves to acquiring knowledge of nuclear physics.

Water-Works Problems in A.E.C.

So far, the operations of the atomic-energy industry have not called on outside water utilities for any extensive service. This is because its production plants are in more or less isolated areas and because the AEC has constructed and operated its own water-utility systems. But water-works planners and operators in this new industry have had problems to face not unlike those of public water utilities. Some of them were resolved under most unusual and difficult circumstances and with most interesting results. For example, the facilities for purification of Columbia River water at the Hanford Works in the State of Washington are now adequate to supply water for the average needs of an American city having a population in excess of 1,500,000 people. Only a few water-purification plants west of the Mississippi are larger, and it is doubtful if any is under more rigid technical control. These plants purify water used to cool the reactors, in which plutonium is produced from prepared uranium. In supplying domestic and irrigation water to the villages of Richland and North Richland, where employees and families of the operating and construction units at the Hanford Works reside in federally controlled communities, a most interesting system for recharging well fields, using Yakima River

water from irrigation ditches and Columbia River water, has been developed. Because of the lack of rainfall in this area and the need of water for irrigating lawns and parkways, the per-capita use of water in these villages, having a total population of less than 25,000, is about 1,100 gal per day.

At Los Alamos, N. M., water from wells in the Rio Grande Valley is pumped, in stages, an elevation of nearly 2,000 ft, in order to supply the housing and operating requirements of the area, which is on a mesa, over 7,200 ft above sea level. Explorations are now under way to ascertain the practicability and cost of developing a supplementary gravity supply from underground sources within the caldera of an extinct volcano. It has taken skilled engineering to develop and to construct these unusual water-supply facilities and to make the necessary extensions to meet increasing demands for water use.

Concern over Radioactive Contamination

One of the most common inquiries received from water-works operators in regard to the development of the atomic-energy industry is concerning the possibility of contamination of sources of water supply by radioactive materials. This concern includes methods of disposal of radioactive wastes from production plants, the increasing spread in the shipment and use of radioactive isotopes throughout the country, the possibility of their being spilled or released to public sewers and perhaps ultimately to contaminate sources of water, and, finally, the hazards involved if radioactive contaminates should ever be used offensively or defensively in time of war. Water-works officials would like to know whether or not they should institute measures to detect radioactivity in their water supply and, if it is found to be present in dangerous amounts, what they could do to remove it. These are all queries which are pertinent in view of the responsibilities of the water-works profession to the public and they merit answers insofar as they can be given.

What Is Radioactivity?

What is radioactivity, that it should be feared as a contaminant of water in much the same way that contamination by infectious organisms or toxic chemicals is now feared? It is high energy radiation, which has the power of ionizing living tissue and destroying cells (1).

In the ordinary sense it cannot be seen, heard, felt, tested or smelled. Radiation is an insidious force of great possibility, which has various forms, each of them having certain characteristics whch must be understood, if they are to be used or worked with effectively. They include alpha and beta particles, X and gamma rays, and neutrons. Some forms cause greater amounts of damage to living tissue than others, but the type of injury is the same. The X and gamma rays and, to some extent, the betas are damaging externally. Therefore, the body must be shielded from them by lead, concrete or other absorbers. The alphas can be shielded against by a piece of paper. Internally the alphas are extremely hazardous, as are also the betas, but to a lesser degree. They are bone seekers and also can cause serious destruction to tissue and vital organs. For these reasons the alpha emitters which may become deposited in the body are especially hazardous. Examples of long-lived alpha emitters are uranium and plutonium. Although most alpha emitters are fortunately not readily absorbed by the body from the digestive tract, they are, nevertheless, contaminants of concern to water-works officials.

The body is selective to radioactive forms of certain elements. For example, radioactive iodine that enters the system is soon found in the thyroid gland; barium and strontium are absorbed in the intestinal tract. The body rejects much radioactivity through its normal excretions. Thus we find that radioactivity as a contaminant, while entirely different from infections and toxic agents, has properties which cause it to attack the body at points which are similarly vulnerable to other contaminants, which we seek to keep out of our public water supplies.

Terms and Tolerances

This leads us to the question of what are the terms used to measure radiation? What are the maximum safe limits of contamination of water and how were they arrived at? First as to units: a number of atoms or molecules of a mass of material which disintegrates in a certain specified time period is known as the curie (c). A curie (2) source of radioactive material is one that disintegrates at the rate of 37 billion atoms per second. It is approximately the rate of disintegration of 1.0 gram of radium. The ionizing effect of radiation on another material is expressed by the term roentgen (r) (2). It is a

unit describing the amount of radiation which is stopped or partly stopped by material in its path, thereby producing ionization, which is the source of damage to human tissue. Other units are: the roentgen equivalent, physical (rep), and the roentgen equivalent, man (rem). Definitions of these and other units are given in the appendix.

About 30 years ago it was observed that in this country and Europe workers with radium and radon under conditions of exposure were experiencing a form of illness resulting from anemia of the blood. Later in the 1920's the tragic story of the exposure and death of workers in the luminous-paint industry was unfolded and studied. As a result of these and other experiences, a series of recommendations was made of so-called safe tolerances for exposure to radiation. Until recently the generally accepted standard of maximum permissible daily dose, as recommended by the National Committee on Radiation, was (2):

Type	*r*	*rem*	*rep*
X-ray	0.1	0.1	0.1
Gamma	0.1	0.1	0.1
Beta		0.1	0.1
Fast neutron		0.1	0.01
Thermal neutron		0.1	0.02 to 0.1
Alpha		0.1	0.01

Modification of the limit of 0.1 r per day to 0.3 r per week is under serious consideration, based on new research findings.

The fact that limits have been established for daily or weekly permissible exposure to radiation does not mean that this rate cannot be exceeded for short periods—indeed, when one's chest is x-rayed, a dosage of 0.1 r is not unusual.

The National Committee on Radiation Protection, on which are represented the Bureau of Standards, the Public Health Service, the Atomic Energy Commission and professional groups of radiologists and x-ray workers, has eight sub-committees which are working on recommendations for standards of safety against radiation. Committees of special interest to water- and sewage-works officials and public-health engineers are the following (1):

Handling of Radioactive Isotopes and Fission Products
Monitoring Methods and Instruments
Waste Disposal and Decontamination

It is expected that some time this fall recommendations for maximum permissible limits of radiation in air and water will be announced. Morgan (3) has suggested the following concentrations of general radioactive contaminants beyond the area of control:

Kind of exposure in	Maximum permissible concentration in micro curies per cc	
	For beta or gamma emitter	For alpha emitter
Water	10^{-7}	10^{-7}
Air	10^{-9}	5×10^{-12}

Radioactivity in Water

It has been known for years and reported on to a considerable extent that certain natural waters are radioactive. According to Morgan (3), the concentration of radioactivity in certain famous American springs, prized for properties for human consumption, are as follows:

Spring	Location	Radioactivity in micro curies per cc of water
Curie	Boulder Springs, Colo	2.6×10^{-4}
Hartsel (hot)	Colorado	4.0×10^{-5}
Mansion	Colorado	1.3×10^{-6}
Pluto	French Lick, Ind.	4.9×10^{-7}
Old Orchard	Missouri	4.3×10^{-7}
Nauheim Glen	New York	2.6×10^{-5}
Kovarek and McKeehan	Ohio	2.2×10^{-6}
Tioga Mineral Wells	Fitch, Tex.	2×10^{-6}
Magnesium	Hot Springs, Va.	9.3×10^{-5}

The fact that certain limited amounts of radioactivity in spring water is not known to be harmful when that water is drunk—and in some instances is thought to be helpful—is, of course, no reason why radioactive contamination of a source of water supply, normally free of detectable radioactivity, should be permitted, if the interests of others

would be affected and it is possible to prevent this effect. Even though this contamination be within permissible safe limits, it should be under strict control. In dealing with radioactivity as a contaminant, much consideration must be given to the length of time this energy will be given off. For example, if an isotope of short half life—say a few hours—is put into a stream at a point below which there are no consumers by flow time within 24 hours, the seriousness of this contaminant would be negligible. On the other hand, in these same circumstances a long-lived isotope could be a serious hazard, even though considerable dilution were possible. This contamination might be picked up and be concentrated in algae, plankton and other forms of lower life, which live in the water of streams and in the mud of the stream bed. The time factor in its effect on decay of radiation and the concentration of radioactivity in biologic forms common to water are extremely important elements in appraising the public-health aspects of this problem.

As Chairman Lilienthal stated (4) at the seminar on disposal of radioactive wastes, sponsored by the Commission and held in Washington, January 24-25, 1949, "We have to learn to live with radiation". At this meeting, which was attended by key representatives of the water- and sewage-works industries and sanitary engineers in public service, representatives of the AEC discussed operations and controls affecting the origin and disposal of radioactive materials and certain public-health aspects of this problem.

Radioactive Wastes

In the atomic-energy industry some radioactive contaminants of low levels of activity are released to public sewers and to nature. For example, at the Hanford Works the highly purified water used to cool the reactors is returned to the Columbia River. But first it is retained for a number of hours in huge basins, to permit decay of the radioactivity which was created when the neutrons in the reactor energized the small amounts of dissolved salts in the cooling water. Before this water is released to the river, it is monitored for radio-activity, in order to be sure that the residual level of radiation is such that, when this water is diluted with the river water, a wide margin of safety will be provided. Similarly, at Oak Ridge the discharge from the waste-

solution holding pond and the subsequent retention facility, known as White Oak Lake, is monitored regularly prior to release of water to the Clinch River. Controls are carried out to limit the release of activity to the Clinch River to not more than 25 curies per week. Morgan reports (3) that the average concentration of radioactivity in this river is 10^{-7} micro curies per cc.

It would be unrealistic to discuss the problem of water contamination with a group of experienced water-works officials wholly in terms of average conditions and normal operating procedures. Experience with spills in industry of product and wastes is a part of the record and such contingencies must be reckoned with in dealing with radioactive, as well as toxic, wastes. The A.E.C. has given this potentiality much consideration and is surrounding its operations with precautions of unusual severity, and at considerable cost, in order to protect its workers and others off-site against the contingency of an accident. Special attention is being given to reduction in the volume of stored wastes and the early reclamation of products which formerly were stored. In case of an accident, extensive plans have been developed in all areas of production for warning water-works and public-health officials of any hazardous conditions and for continual monitoring of any areas which may be affected. The A.E.C. has made arrangements with the Geological Survey to study the geology of sites and possibility of groundwater contamination as a result of its present and future operations at Los Alamos and Hanford, and work is already under way. Similar surveys were made in connection with the national laboratories at Brookhaven (Long Island), Argonne (near Chicago) and Oak Ridge, Tenn., the last being in coöperation with the Department of Geology, University of Tennessee. In the selections of sites for plants near Schenectady, N. Y., and Arco, Ida., the Geological Survey conducted field investigations. The coöperation of the Weather Bureau has been received in connection with meteorological controls at several areas of operation. The Public Health Service has assigned specialists to assist in waste-disposal research programs at Oak Ridge and Los Alamos.

Radioactive Isotopes

As to concern on the part of some public-works and -health officials that distribution, use and disposal of isotopes may create a problem of contamination of water supplies, it is true that the use of these materials is increasing. However, hazards involved are relatively less than those at production areas. The A.E.C. Isotopes Division Circular B-6 (6) contains interim recommendations for the disposal of radioactive wastes by off-commission users.

More than 6,350 shipments (1) of radioactive isotopes were made from August, 1946, to June, 1949, to 41 states and territories and to 309 institutions. They are used for research in medicine, biology, chemistry, agriculture, industry and other arts and sciences, and users are required to meet strict standards in the use and disposal of these isotopes. The more commonly used isotopes have short half lives and therefore lose their radioactivity in a matter of minutes, hours, days or weeks, as compared with uranium and plutonium, which have half lives of 5 billion and 25 thousand years, respectively. The exception is carbon (C^{14}) which has a half life of 5,100 years. A summary of the half life of some of the more common isotopes of interest to water-works officials and in current use is given in the following table (5):

Element	Symbol	Atomic number	Mass no. of isotope	Half life	Type of radiation
Arsenic	As	33	76	26.8 hr	B−, C
Barium	Ba	56	131	12. da	K, e−
Carbon	C	6	14	5,100 yr	B−
Chlorine	Cl	17	36	1,000,000 yr	B−
Copper	Cu	29	64	12.8 hr	B±, K, C
Iodine	I	53	131	8. da	B−, C
Iron	Fe	26	55	4. yr	K, C
Phosphorus	P	15	32	14.3 da	B−
Potassium	K	19	42	12.4 hr	B−, C
Silver	Ag	47	110	225 da	B−, C
Sodium	Na	11	24	14.8 hr	B−, C
Strontium	Sr	38	89	55 da	B−
Zinc	Zn	30	65	250 da	B+, K, e−, C

B−—beta particle emitted; B+—beta particles emitted
K—electron capture; e−—internal conversion
C—gamma radiation

Research

At Los Alamos and Oak Ridge, as well as at Johns Hopkins and New York Universities, research is in progress to determine the effect, if any, of radiation of various types of micro-organisms and processes common to sewage treatment. It is recognized that concentration of radioactivity in biologic slimes in sewers and pipes could create a hazard to maintenance workers and provision is made to have such facilities monitored for radioactivity before repairs are made.

In the matter of decontamination of water supplies, should they become accidentally contaminated by a spill or as a result of military action in which radioactive materials were used, much attention has been given to the problem with which a water utility so affected would be faced. It is known that radioactive materials become readily attached to soils and vegetation. This phenomenon itself has great possibilities in decontamination, although its positive effects and limitations are not fully understood.

Those water-works which have no treatment facilities for removing dissolved and suspended matter from water would be subject to the greatest hazard, although the factor of dilution would be helpful. Even the protection of attachment of radioactivity to the bottom of reservoirs would be rendered ineffective during periods when the seasonal turnover of the reservoir occurred or when, for other reasons such as a high wind, the equilibrium of the water in the reservoir was disturbed. Where chemical coagulants are used, followed by mixing, flocculation and settling, a substantial percentage removal of radioactivity can be brought about. In such cases, if the contaminant is a long-lived radioactive substance, the settled sludge presents a problem. If settling-basin sludge or wash water is released to a stream or waterway as is customary, a concentrated "slug" of radiation would result, decreasing in activity as dilution in the stream took place. Some storage facility, such as a basin or a lagoon, would be required and provision should be made to monitor it, as well as the pumps and piping used in the transfer of the sludge or wash water.

Filtration offers further means of decontamination. Research programs sponsored by A.E.C. are underway at the Oak Ridge National Laboratory and the Massachusetts Institute of Technology, to determine the relative effectiveness of various methods and facilities now in

use in water-purification works in this country. These tests will include runs with a variety of chemical coagulants, different periods of mixing and settling, and various types and rates of filtration. Should it be found that standard methods and procedures are not sufficient for decontamination, research will be continued in an effort to determine whether or not, by supplemental treatments, efficiencies of decontamination can be increased. This will include study and use of artificial absorbents added to the raw water, such as those used to remove odors or to improve coagulation, and the use of natural and synthetic ion-exchange media in the basins and on the filters. As soon as useful data are obtained from these research projects, they will be made available to all who are concerned or interested. Obviously, these studies will require several years to complete, but a start has been made and the projects can be expanded as necessary.

Shortage of Trained Personnel

One of the limitations in carrying out such research is the paucity of experienced water-works technicians who have knowledge of nuclear physics, experience in the use of instruments required for measuring radiation, and ability to interpret results obtained. Present methods of making radiological assays of water are time-consuming and cumbersome. Efforts are being made to develop equipment and instruments which will simplify them. Such efforts are not new to the chemist or bacteriologist who has worked on chemical, bacteriological and microscopic analyses of water and sewage, but they do require training, experience and trial at a time when there is great need of instruments for other uses in the atomic-energy industry and when properly trained sanitary chemists and engineers, who have knowledge of the fundamentals of water-works and nuclear physics, are rare.

Need of Training Program

This leads us to the need of training technicians in the water-works profession in nuclear physics and interesting young men who have studied nuclear physics in the water-works aspects of the atomic-energy industry. Tentative plans for such training programs have been discussed. Putting them into shape for adoption and subsequently carrying them out will call for coöperation of a high order between the two industries.

Radiological Laboratory Requirements

Officials of some water utilities have shown an interest in purchasing instruments to determine the radioactivity of their water supplies and to assist in carrying out experimental work involving the use of radioactive tracer material. It seems inadvisable to proceed along these lines until the research worker has had a thorough indoctrination in nuclear physics, radiological techniques, the use of instruments and the interpretation of results. Otherwise, highly erroneous and misleading results might be obtained.

The cost of building a laboratory for research into the properties and characteristics of radiological materials and of equipping it with the proper instruments and facilities for work and control is much greater than for any ordinary water-analysis laboratory. The laboratory should be separated from other work units; its physical arrangement should be such as to provide against the possibility of even slight losses of radioactive materials, to say nothing of spills. Surfaces of floors, benches and sinks must be of materials which can be readily decontaminated by solutions, abrasives or other means. Covering of such surfaces by strippable material has been used in some laboratories. All contaminated material should be disposed of by approved methods and in safe locations. If such material is burned, products of combustion should be decontaminated and the ash buried with adequate coverage for shielding. Radioactive material should be stored in special containers, which will give proper protection against radiation. All surfaces and working spaces should be monitored regularly. Contaminated glassware and instruments should be disposed of by burial in a safe space. Workers may be required to wear protective clothing and gloves and, unless destroyed, wearing material should be laundered by special methods and chemicals, after which the laundry wastes should be monitored and decontaminated in a safe way. Some of these wastes are very difficult to treat by either chemical or biological processes. Ventilation should meet strict standards and the exhaust air, fumes and mists from hoods should be decontaminated by filtration or some other effective means. It would be well for water-works laboratory workers and planners to become thoroughly familiar with the requirements of a radiological laboratory before designs are undertaken.

Use of Radioactive Tracers for Research in Water Works

Finally, we come to the possibility of using radiation as a research tool in the water-works industry. Already in the oil industry wells are being logged by radiological methods, using neutrons (7) and gamma rays (8). The absorption of radioactivity by plankton, algae and other biological forms of life common to water opens another avenue of interest to the water-works operator whose troubles with these organisms are of serious nature. The use of radioactive-tracer techniques offers a real opportunity to study the phenomena of flocculation, coagulation and settling. What goes on in rapid and slow sand filters and the phenomenon of ion exchange should be traceable by means of radioactive isotopes. Other possibilities are: the flow of water in pipes; the causes and effects of corrosion; studies of joint compounds and their use, and perhaps the mechanism by which chlorine acts as a germicide. It is reported that in France a research worker (9) has developed a proton microscope, which gives magnification six times that of the electron microscope.

In conclusion, if we consider the fact that the atomic-energy industry is in its infancy and that day by day new methods and techniques using radiation are revealing secrets long under seal against mankind, is there any reason why the water-works and atomic-energy industries, which have so much in common, should not give one another a lift on the way to a better life for all of us?

Definitions

Atom (9)—the smallest unit of which a chemical element is built. The simplest atoms are those of hydrogen; the most complex, those of uranium.

Chain reaction (9)—a term appled to any chemical or nuclear transmutation process in which some of the products of a particular change assist the further development of that change.

Curie (2).—The curie is a number of atoms or molecules in a mass of material which disintegrates in a certain specified time period. A curie source of radioactive material is a source that disintegrates at the rate of 37,000,000,000 (written 3.7×10^{10}) atoms per second. A micro curie is one millionth of a curie.

Ionization (9)—the process by which an atom which is ordinarily electrically neutral acquires an electrical charge. An atom thus ionized is called an ion.

Isotope (9)—a species of an element in which the atoms are of uniform atomic weight.

Roentgen (r) (2) is a unit describing the amount of the radiation's energy

which is stopped (or partially stopped) by material in its path, thereby producing ionization, which is the source of damage to human tissue. It is a quantity of X or gama radiation which produces a certain specified amount of ionization in air.

Roentgen equivalent physical (rep) (2) is a quantity of radiation which produces a certain specified amount of ionization in tissue.

Roentgen equivalent man (rem) (2) is that quantity of radiation which, when absorbed by man, produces an effect equivalent to the absorption by man of one roentgen of X or gamma radiation.

References

1. Sixth Semi-Annual Report, U. S. Atomic Energy Commission. Government Printing Office, Washington 25, D. C.
   Loeb, D. B. "Radium Poisoning in Water", Jour. Am. Water Works Assoc., p. 461-476, April, 1934.
2. "Radiation and You"—Radiation Laboratory, University of California, Berkeley, Cal., April, 1948.
3. Morgan, K. Z. "Radioactive Contamination and Control". A. E. C. Seminar on Waste Disposal, Washington, D. C., January 24-25, 1949.
4. Digest of Proceedings, Seminar on the Disposal of Radioactive Wastes, Washington, D. C., January 24-25, 1945. Atomic Energy Commission.
5. Fourth Semi-Annual Report, U. S. Atomic Energy Commission. Government Printing Office, Washington 25, D. C.
6. Interim Recommendations for the Disposal of Radioactive Wastes by Off-Commission Users, Isotopes Division Circular B-6, A. E. C., Isotopes Division, Box E, Oak Ridge, Tenn.
7. Fearon, R. E. "Neutron Well Logging", Nucleonics, 4, 30-42, June, 1949.
8. Fearon, R. E. "Gamma Ray Well Logging", Nucleonics, 4, 67-75, April, 1949.
9. Magnan, Claude. "Proton Microscope", Nucleonics, 4.
10. Morgan, K. Z. "Health Physics and Its Control of Radiation Exposures at the Clinton National Laboratory", Chemical Engineering News, 25-3794, September, 1947.
11. Morgan, K. Z. "Hazards Presented by Radioactive Materials and How to Cope with Them," U. S. Naval Bulletin, Supplement, p. 142-160, March-April, 1948.
12. Morgan, K. Z. "Protection Against Radiation Hazards and Maximum Allowable Exposure Values", Jour. Ind.-Hygiene and Toxicology, 30, 286-93, 1948.
13. Morgan, K. Z. "Tolerance Concentrations of Radioactive Substances", Jour. Physical and Colloidal Chem., Vol. 51-894, 1947.
14. Parker, H. M. "Health Physics, Instrumentation and Radiation Protection", MCC-783. Technical Information Division, A. E. C., P. O. Box E, Oak Ridge, Tenn.
15. Morgan, G. W. "Surveying and Monitoring of Radiation from Radioisotopes", Nucleonics, Vol. 4, No. 3, March, 1949.
16. Levy, A. A. "Some Aspects of the Design of Radiochemical Laboratories",

Chem. & Engr. News, Vol. 24, 3168, 1946.
17. Sullivan, W. H. "Control of Radioactive Hazards", Chem. & Engr. News, Vol. 25, 1862, 1947.
18. Gorbman, Audrey. "Radioautography in Biological Research", Nucleonics, Vol. 2, No. 6, 30-42, June, 1948.
19. Cohn, W. E. "Toxicity of Inhaled or Ingested Radioactive Products", Vol. 3, 21-22, July, 1948.
20. Cohn, W. E., Parker, G. W., and Tompkins, E. R. "Ion Exchangers to Separate, Concentrate and Purify Small Amounts of Ions", Nucleonics, Vol. 3, p. 22-33, November, 1948.
21. Symposium on Radiochemistry Laboratories, Ind. Engr. Chem., 41, 228-50, 1948.
22. Glossary of Scientific Terms Relating to Atomic Energy, U. S. A. E. C., Washington, D. C.

Discussion

E. Sherman Chase (Boston, Mass). If it is not asking for the disclosure of confidential information, I should like to inquire to what extent the New England water-works systems are likely to meet up with the problem of radioactive contamination of water supplies. That may be out of order; if so, it will not hurt my feelings to be told so.

Arthur E. Gorman. From the standpoint of the use of isotopes I think the exposure will be very low. Of course, we have no production areas in New England, outside of Brookhaven. As I said before, all the production areas are under strict control. The only other hazard which you have is what might happen in case of radioactive warfare. Of course, what that contingency will be we do not know but when the research is done at M.I.T., at Johns Hopkins and at Oak Ridge, if they should have something that indicates hazard, we expect at that time to have the information so that we can give it to you. I can't discuss that phase of it any further.

George E. Symons (New York, N. Y.). What is the half life of carbon?

Mr. Gorman. 5,100 years.

Mr. Symons. Why did you use cc instead of ml, where all chemists in the world use ml?

Mr. Gorman. I don't know whether we are going to be able to swing these nuclear physics over to our standards or not. There is one thing we must get in connection with standards and nomenclature, so that it will be understood. The thing which I want to emphasize most of all is our young men and I turn to you, who are employing

young men and who are training young men. From that angle, from what I have seen, I think all of you who have a responsibility for the education and training of young men ought to be very sure that they get good instruction in nuclear physics, so that when problems come up in industry, they can be handled by these men who are keen. It is very complicated, and the ramifications are so much greater than those involved in toxic chemistry or infectious bacteriology and the things that go along with it. Unless you want this line of work to go into the hands of those who know nothing about water supply, you had better get some boys who know water works and also know nuclear physics trained in this industry, so that they can continue to give the service.

MR. SYMONS. Didn't I read in some magazine not long ago that they were going to move Los Alamos?

MR. GORMAN. You may have read it. I don't know anything about it.

MR. SYMONS. I just wondered if it had anything to do with the water supply.

MR. GORMAN. No, I think not. I have not read it.

MR. SYMONS. Are there any training courses now being given?

MR. GORMAN. There are training courses being given for radiologists at the School of Nuclear Physics at Oak Ridge. As I have indicated, we are working on a program to extend that to other professional groups. We are giving consideration to an early extension into the field of public-service engineering and eventually into our field. The number of available tutors and the facilities for instruction are limited. The six weeks' courses that are now being given for radiologists are really not suited for the type of things you folks would want. We are working with the National Research Council committees, which you are all familiar with, and they will be coöperating with us this fall on several problems, one of which will be the program of training our young men and another will be training of the men who are already in the industry, who can go there and in a comparatively short period of time get some of the fundamentals. I don't think that there is any short course giving basic instruction. Men like Roy Morton, Clarence Reichtroft and Otto Placek strongly recommend that people get good basic training. Men can come in and in a matter of a short time can get some general training, but they feel it would be unwise for a new man to try to do anything in less than a year on this work, if he is going to carry any responsibility.

OBSERVATIONS ON WATER SAMPLES FROM CEMENT-ASBESTOS PIPE SYSTEMS IN VERMONT

BY EDWARD L. TRACY*

[*Read September 15, 1949.*]

PROBABLY many complex problems start in a simple way or with a simple question. The problem of the effect of cement-asbestos pipe on water in our Vermont public water systems certainly began with what seemed to me an easy question, at the time. At Brattleboro, in the summer of 1945, the water superintendent asked me if it should be expected that, in the north end of the village along highway U. S. 5, the water should have a high pH and a noticeable increase in hardness. Had I realized what the answer might involve, I probably would have dodged the question or ignored it, in the hope that the problem would disappear.

The area in question is supplied by about two miles of cement-asbestos pipe, laid north along highway U. S. 5, beginning about one-half mile north of the center of the village. The pipe had then been in use about four years, since 1941. The lengths of different sizes of pipe in this line are not known accurately by me, but I believe it is reasonable to assume an average pipe diameter of 8 in. for this discussion. It was often assumed that cement-asbestos pipe stabilized in one or two years of use and it was with that thought in mind that I began to answer the superintendent's question. I started to check the pH of the water north of the junction of the cement-asbestos pipe with the old cast-iron pipe of the distribution system. The Brattleboro water, at the center of the village, has an average pH of about 7.2 and an average hardness of around 35. My first attempted check on pH was about ¾ mile north of the beginning of the cement-asbestos main and, somewhat to my surprise, the pH was beyond the range of bromthymol blue, which is used in the comparator I was carrying.

Three water samples were then collected for laboratory analyses. One was from the center of the village, one two miles north or about

*Director, Sanitary Engineering Division, Vermont Department of Health, Burlington, Vermont.

1.5 miles north of the beginning of the cement-asbestos pipe, and the third sample was taken ½ mile farther north, near the dead end of the 2 miles of cement-asbestos pipe. There are only a few service connections in this last half-mile and probably there is very slow circulation of water in the pipe.

The results of the analyses were quite surprising to me. In the 1.5 miles of cement-asbestos pipe between the first two samples, the pH increased 28%; hardness increased 60%, and total alkalinity increased 30%. In the total two miles of cement-asbestos pipe, the pH increased 38% to 9.9; the hardness increased 90% to 57, and the total alkalinity increased 83% to 55.

We, in the Public Health Department, decided to make some observations on another cement-asbestos pipe distribution system in South Shaftsbury. This pipe was installed about 1940. The community purchases water from the North Bennington main, which crosses through the village, to supply 370 people. The North Bennington reservoir is a short distance east of South Shaftsbury. The major part of the community, as well as the major water consumption, is along highway U. S. 7. Samples were taken at the North Bennington reservoir, at a South Shaftsbury tap on U. S. 7—0.6 mile north of the junction with the cast-iron supply main—and at a tap on a dead-end main, west of the main highway and 1.2 miles from the beginning of the cement-asbestos pipe, which, I believe, is mostly 6 in. in diameter.

The reservoir water has an average pH of about 6.9 and an average hardness of 27. The analyses of the samples, taken after about five years of pipe service, showed that the change in water characteristics was not very great along the main street, where the circulation is probably the maximum in the village, but it was greater at the western dead end. In the first 0.6 mile of cement-asbestos pipe the pH increased 3%; the hardness increased 8%, and the total alkalinity increased 25%. In the total 1.2 miles of cement-asbestos pipe from the beginning of the system to the western dead end, the pH increased 45%; the hardness increased 87%, and the total alkalinity increased 191%. These increases were as great as, or greater than, we had observed in Brattleboro.

For an additional check on whether we had struck some freak conditions of circulation, on both the water systems observed, that

were misleading rather than typical, we collected samples in South Burlington in November, 1945. This is a cement-asbestos distribution system, which had then been in use about 9 years. The community is directly east of Burlington and Burlington water, delivered entirely through a cast-iron pipe system in Burlington, is purchased at the east city line.

Burlington water at that point has an average pH of 7.2 and an average hardness of about 55. Samples were collected at the east city line, at a point 1.1 miles east, where the circulation is maximum for the South Burlington distribution system, and at the eastern dead end, 1.9 miles from the Burlington city line. Most of the South Burlington distribution-system pipe is believed to be 6 in. in diameter.

In the first 1.1 miles of cement-asbestos pipe the analyses were even more favorable than in the first 0.6 mile of the South Shaftsbury system, as would be expected, since the pipe had been in use about twice as many years. The increase in pH in the first 1.1 miles was only 3%; there was no change in hardness, and the total alkalinity increased only 11%. In the 1.9 miles of cement-asbestos pipe, from the east Burlington city line to the eastern South Burlington dead end, the change was greater but still very reasonable. The pH had a total increase of 17%; the hardness was still unchanged, and the total alkalinity had increased 19%.

This set of observations seemed to indicate that cement-asbestos pipe became stabilized, so that it did not seriously change the characteristics of the water, but the stabilization was much slower than I had previously assumed. Since all of the areas or communities were small in population it seemed reasonable to conclude that the stabilization process was directly related to the flow or circulation of water through the pipes. Perhaps this should have been obvious from the start, but I had not obtained information, as a result of my previous inquiries, that would indicate any rule for predicting the rate of stabilization, based on circulation or contact time.

Again in 1946 the entire procedure of sampling and analyzing Brattleboro and South Shaftsbury water was repeated at the same sampling points. Generally speaking, the increase in pH, hardness and total alkalinity was less than it had been in 1945 but it was still considerable.

In 1949 another set of analyses was made, after 8 to 9 years' use of the Brattleboro and South Shaftsbury cement-asbestos pipe systems. The increases in pH, hardness and total alkalinity are now roughly comparable with the conditions in South Burlington in 1945, when that pipe had been in use for nine years. There was one exception to this trend. In South Shaftsbury the increase in pH through the cement-asbestos pipe system was greater than it had been in 1946, but the hardness and total-alkalinity increases were considerably less.

The South Burlington system was sampled again in 1949 and, in general, the increases in pH, hardness and total alkalinity, at the same points as previously sampled, are now so small as to be practically negligible, when compared with the changes I have been discussing. After 13 years of use the South Burlington cement-asbestos pipe can now be considered practically stabilized, so that it does not appreciably change the characteristics of water flowing through it. In 1948, 1.2 miles of new cement-asbestos pipe were added to the east end of this South Burlington distribution system. After about one year of use the increase in pH through the complete 3.1 miles, from the Burlington east city line to this new South Burlington easterly dead end, is 11%.

The increase in hardness through the same distance is 29% and the total alkalinity increases 17%. The increases through the 1.2 miles of new pipe, however, are so much less after only one year of service than were observed in Brattleboro and South Shaftsbury after 4 or 5 years service, that it seems obvious that cement-asbestos pipe such as was delivered to South Burlington in 1948 is much more stable and has much less effect on water than the pipe which was being delivered about 10 years ago.

A new water-supply and distribution system was completed in 1948 in Proctorsville, a community with a population of about 650 in south-central Vermont. Water is furnished by a gravel-packed well in the northwest corner of the community. All of the pipe system is cement-asbestos, mostly in 6-in. and 8-in. sizes. A 150,000-gal concrete standpipe, at the north end of the community, rides on the water system. The complete system had been in use a little over a year when samples were collected in early 1949. The well water has a pH of 7.3 and hardness of 74. In a distance of 0.8 mile to a dead end in

the south end of the community, the pH increases 5%; hardness does not increase, and total alkalinity increases 89%.

In South Troy, in the extreme northern end of Vermont, a cement-asbestos supply main and a similar distribution system have been in continuous use since about 1936. This village has a population of 250. No analyses which can be used for comparisons, such as are being made in this discussion, were made until 1949. A sample was taken from the reservoir and another sample from a tap at the east end of the community, after the water had passed through 1.3 miles of 6-in. cement-asbestos pipe. There was no increase in pH, hardness or total alkalinity. The water has a pH of 7.4, hardness of 30 ppm and total alkalinity of 14 ppm. This is certainly an example of stabilized cement-asbestos pipe, at least with water having a pH above the neutral point.

I should like to emphasize that I do not pretend that a complete research project has been conducted by the Vermont Department of Health on the effect of cement-asbestos pipe on the characteristics of water flowing through it. The words in the title for this paper were purposely chosen, because I consider that we have simply gathered observations of water characteristics under varying and uncertain conditions of rate of flow through the pipes. However, it appears evident that in small communities, where the amount of water consumed is small and hence the rate of circulation is slow, the cement-asbestos pipe laid eight or ten years ago had a considerable effect on pH, hardness, and total alkalinity, even when the pH of the water to start with was above the neutral point. It also appears evident that, if we allow time enough to compensate for the low rate of flow, the tendency of this older cement-asbestos pipe to raise pH, hardness and total alkalinity greatly diminishes. The most recent South Burlington and Proctorsville observations point out that the newer cement-asbestos pipe has much less tendency to change the characteristics of water flowing through it, even though the rate of flow be small.

BRATTLEBORO
(Installed in 1941)

	Center of village			N. 1.5 mi on cement-asbestos pipe			N. 2 mi at dead end		
	9/45	8/46	4/49	9/45	8/46	4/49	9/45	8/46	4/49
Turbidity	1	1	1	1	1	1	2	2	1
Sediment	1	1	1	0	1	1	2	3	1
Color	0	20	15	0	25	15	30	25	15
Odor	1	0	0		0	0	1	0	0
pH	7.2	7.2	7.5	9.2	9.1	8.2	9.9	9.6	8.6
Hardness	30	31	46	48	48	40	57	51	42
Total alkalinity	30	24	24	41	36	27	55	50	30
Chlorides	0.5	0.7	1.1	0.7	0.6	1.0	1.2	0.7	2.5
Albuminoid	0.042	0.054	0.042	0.048	0.054	0.048	0.048	0.060	0.048
Ammonia	0.024	0.018	0.024	0.024	0.018	0.024	0.024	0.024	0.012
Nitrites	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitrates	0.05	0.0	0.24	0.05	0.05	0.14	0.05	0.0	0.15
Coliform	—	—	—	—	—	—	—	—	—

SOUTH SHAFTSBURY
(Installed in 1940)

	Reservoir			N. 0.6 mi on cement-asbestos pipe			N.W. 1.2 mi at dead end		
	10/45	9/46	'49 ave.	10/45	9/46	5/49	10/45	9/46	5/49
Turbidity	1	1	1	0	1	1	0	1	1
Sediment	1	1	0	1	1	1	1	1	1
Color	0	5	0	0	20	3	0	0	5
Odor	0	0	1v	1	1	1v	0	2m	0
pH	6.6	7.3	7.2	6.8	7.8	8.3	9.6	8.4	9.5
Hardness	24	29	32	26	29	24	45	50	40
Total alkalinity	12	20		15	22	12	35	41	26
Chlorides	0.0	0.8	0.5	0.0	1.4	0.0	0.0	1.6	0.3
Albuminoid	0.078	0.066	0.045	0.060	0.054	0.066	0.042	0.042	0.180
Ammonia	0.030	0.072	0.082	0.030	0.024	0.103	0.018	0.018	0.027
Nitrites	0.0	0.001	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitrates	0.1	0.2	0.49	0.1	0.3	0.14	0.1	0.25	0.14
Coliform	—	—	—	—	—	—	—	—	—

SOUTH BURLINGTON
(Installed in 1936; extended in 1948)

	City line		E. 1.1 mi on cement-asbestos pipe		E. 1.9 mi at dead end		E. 3.1 mi at new dead end after 1948
	11/45	8/49	11/45	8/49	11/45	8/49	8/49
Turbidity	1	0	1	0	1	0	0
Sediment	0	0	0	0	0	0	0
Color	0	0	0	0	0	15	0
Odor	1m	1e	1m	0	1m	0	1e
pH	7.0	7.4	7.2	7.4	8.2	7.5	8.2
Hardness	54	46	54	50	54	74	72
Total alkalinity	37	41	41	42	44	45	48
Chlorides	1.7	10	2.1	12.0	1.9	8.3	8.2
Albuminoid	0.054	0.030	0.021	0.030	0.048	0.024	0.042
Ammonia	0.014	0.0	0.021	0.0	0.018	0.0	0.0
Nitrites	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitrates	0.1	0.14	0.1	0.28	0.1	0.27	0.04
Coliform	—	—	—	—	—	—	—

	Proctorsville (Installed in 1948) 1949		South Troy (Installed in 1936) 1949	
	Well	S.W. 0.8 mi at dead end	Reservoir	E. 1.3 mi at dead end
Turbidity	0	1	1	0
Sediment	0	1	0	0
Color	0	0	10	10
Odor	0	0	1e	0
pH	7.3	7.7	7.4	7.3
Hardness	74	70	30	30
Total alkalinity	26	49	14	14
Chlorides	41.4	44.8	0.1	0.3
Albuminoid	0.036	0.036	0.084	0.054
Ammonia	0.024	0.024	0.030	0.018
Nitrites	0.0	0.0	0.0	0.0
Nitrates	0.90	0.96	0.26	0.22
Coliform	—	—	—	—

Increases in pH

	1945	1946	1949
Brattleboro, first 1.5 mi of cem.-asb. pipe	28%	26%	9%
Brattleboro, total 2.0 mi of cem.-asb. pipe to dead end	38%	33%	15%
South Shaftsbury, first 0.6 mi of cem.-asb. pipe	3%	7%	13%
South Shaftsbury, total 1.2 mi of cem.-asb. pipe to dead end	45%	15%	32%

	1945	1949
South Burlington, first 1.1 mi of cem.-asb. pipe	3%	0
South Burlington, total 1.9 mi of pipe prior to 1948	17%	1%
South Burlington, total 3.1 mi of pipe after 1948		11%
Proctorsville, 0.8 mi cem.-asb. pipe to dead end		5%
South Troy, 1.3 mi cem.-asb. pipe to dead end		0

Increases in Hardness

	1945	1946	1949
Brattleboro, first 1.5 mi of cem.-asb. pipe	60%	55%	0
Brattleboro, total 2.0 mi of cem.-asb. pipe to dead end	90%	65%	0
South Shaftsbury, first 0.6 mi of cem.-asb. pipe	8%	0	0
South Shaftsbury, total 1.2 mi of cem.-asb. pipe to dead end	87%	72%	25%

	1945	1949
South Burlington, first 1.1 mi of cem.-asb. pipe	0	0
South Burlington, total 1.9 mi of pipe prior to 1948	0	32%*
South Burlington, total 3.1 mi of pipe after 1948		29%
Proctorsville, 0.8 mi cem.-asb. pipe to dead end		0
South Troy, 1.3 mi cem.-asb. pipe to dead end		0

*This sample, taken near junction of old and new cement-asbestos pipe, may have been affected by new pipe in 1949, to show increase in hardness, whereas there was no increase in 1945.

INCREASES IN TOTAL ALKALINITY

	1945	1946	1949
Brattleboro, first 1.5 mi of cem.-asb. pipe	30%	50%	13%
Brattleboro, total 2.0 mi of cem.-asb. pipe to dead end	83%	108%	25%
South Shaftsbury, first 0.6 mi of cem.-asb. pipe	25%	10%	0
South Shaftsbury, total 1.2 mi of cem.-asb. pipe to dead end	191%	105%	62%

	1945	1949
South Burlington, first 1.1 mi of cem.-asb. pipe	11%	2%
South Burlington, total 1.9 mi of pipe prior to 1948	19%	10%
South Burlington, total 3.1 mi of pipe after 1948		17%
Proctorsville, 0.8 mi cem.-asb. pipe to dead end		89%
South Troy, 1.3 mi cem.-asb. pipe to dead end		0

DISCUSSION

A MEMBER. Was all this pipe of the same manufacture?

EDWARD L. TRACY. I do not believe so.

ARTHUR C. KING (Taunton, Mass.). Did you reach any conclusion as to the source of the water—that is, does well water or surface water make any difference in the result?

MR. TRACY. We have no basis for a conclusion up to now on this information. You see, we have only one well involved, and in one year that did not show very great changes as compared to the other places. The other waters were all surface waters.

A MEMBER. Some of that was filtered and some unfiltered?

MR. TRACY. One of them was filtered.

THE MEMBER. Burlington being filtered?

MR. TRACY. Yes.

THE MEMBER. It strikes me that there is a possibility that in an investigation of this sort your results may be somewhat clouded by the presence of vegetable matter, or anything of that sort, in the water, which would at least conceivably form somewhat of a coating on your distribution system. That could somewhat complicate your analyses or assignment of a reason for any variation in the time element involved in reaching a stabilization point.

PERCY A. SHAW (Manchester, N. H.). Did you dig up any of this pipe to see what the physical effect was of this loss of lime?

MR. TRACY. No. Our personnel was limited and there was nobody to whom we could pass the buck, for when it came to digging up the pipe, I should want to pass the buck. I did not see any of the pipe involved in this report dug up. I know it has been. For instance, in South Burlington, when they made that extension in 1948, the end of the 1936 pipe was dug up. But I did not make any observations on those myself.

MR. SHAW. If you get some of those pipes dug up, give them a physical examination and report on them, I think it would be very helpful.

MR. TRACY. If I have time, I will.

THOMAS R. CAMP (Boston, Mass.). I think you are in a position to make some quantitative computations on the basis of the alkalinity increase by loss in weight of the pipe. You can make a guess—it does not need to be accurate—on the amount of water that had passed through the pipe, on the basis of the number of consumers at various intervals along the pipe. That information ought to be of considerable value.

MR. TRACY. I think there are a lot of possibilities for carrying this on and really finding out some answers, but it probably should be backed up with observations under laboratory conditions.

D. C. CALDERWOOD (Nashua, N. H.). Maybe I can help out a little, not necessarily from accurate information but regarding a Transite line that was installed in 1934. It has been in service since that time and, to give you the complete story, the "city fathers" decided to install a sewer in that street this past summer. It was in a running-sand soil. Our pipe had about a 5-ft cover and they were going down about 15 ft for their sewer pipe. Their method of construction was

just to keep on digging until they got the hole made. It was a 40-ft street. The result was that the water pipe and about everything else in the street was at the bottom of the hole before they got through. The upshot of it was that we had to re-lay all our pipe in that street and every other utility in the street had to be re-laid.

But the point I wanted to bring out is this: In this sandy soil the pipe on the outside looked just as it did the day it was put in. It was not the least bit spotted. You could even see the paint marks on the pipe, which were put on in 1934. On the side it had a bit of a brownish color, but it was good and solid, and apparently it is in as good shape as the day it was put in. When it was moist and wet, there was a very thin film on the interior, but the minute it stood on edge and drained and dried a little bit, it was as solid as could be. The soil condition was favorable; the water may be favorable, but the pipe also was in very good shape. There was no ground water there to bother; it was in dry soil.

A. J. MAAHS (of Johns-Manville Co.). The question was asked as to the amount of penetration at a period of time after contact with soft water. We had occasion to dig up a piece of pipe 9½ years old. The water there was very soft; it had a hardness of about 22 ppm. The penetration, which was all we could get, due to the very delicate method of scraping, was 0.012 in. in 9½ years. If anybody would like further detail on that examination, I should be glad to give it to him and discuss it with him at any time.

E. SHERMAN CHASE (Boston, Mass.). I should like to ask Mr. Tracy if his samples were taken with the temperature of the water just about the same.

MR. TRACY. Most of them. There was one exception to that. Those first South Burlington samples were taken in November, 1945, when the temperature would be quite a little lower than the Brattleboro and Shaftsbury samples, which were taken that summer. I think they would be a little lower than they would have been had they been taken at the same time in the summer. In other words, the water comes from Lake Champlain and there is quite a temperature variation there between summer and winter. It is just barely above the freezing point in the winter and in the shallow bays on the east side of the lake it gets pretty warm in the summer. Then there would be

another situation, and that is that the Proctorsville well water would probably have a lower temperature than the surface water. But most of the other samples would be about the same.

MR. CHASE. Between the first set of samples and the second set of samples, was each set taken about the same time of year and about the same temperature?

MR. TRACY. That is right. There may have been a variation of a month or two. There was a variation of a few weeks on this 1949 set of South Shaftsbury samples. It is about 110 miles, I guess, from Burlington to South Shaftsbury. I had the Brattleboro samples and I wanted to get some South Shaftsbury samples about the same time. I drove to South Shaftsbury, got samples and turned them in to the laboratory, and a little while later the chief chemist said, "I am sorry, but one of the people in the laboratory did not know that you wanted total alkalinity on those samples, so that they are down the drain." I said, "That is fine; it is 220 miles to get some more." That was one variation.

JOHN B. DONOHOE (of Keasbey & Mattison Co.). I can't go into too much detail, but in reference to the Brattleboro job we were concerned by some of the comments that had occurred up there and, unbeknown to Mr. Tracy—in fact, before he started his investigation—we did some of our own. We had somebody from Philadelphia come up and run some tests for us. If I had known we were to have this talk today, I should have had some data available to substantiate our contention that, as far as this total leaching is concerned over the period, it would become completely negligible. As far as any loss of structure—of the steel thickness—is concerned, to all intents and purposes it is negligible.

L. H. ENSLOW (New York, N. Y.). It is evident to me that the Transite people have found a method of stopping, or at least modifying very materially, this leaching. I am going to ask both of these gentlemen to tell how they did it.

MR. MAAHS. The hardness picked up; the alkalinity picked up; and the pH increased, as indicated by Mr. Tracy. Do you feel that that is a sufficient factor to justify any serious consideration? There had been no consumer complaint. There was one industrial complaint, which is on the record. From an industrial standpoint, there will be industries which will require special waters. In some of the products

we make, we have found it desirable to come to New Hampshire, partly because of the water condition. The water was favorable to a manufacture of that product. But we use Transite pipe throughout the mill. We use Transite pipe to convey the water from the pond to the mill and distribute it throughout the mill, and we do not find that is enough to affect the quality of our product. There is a case where certainly we were going to the expense of selecting a location where water is of the kind that we want, and then we use an asbestos-cement pipe. If we changed it we would be wasting money which we spent in moving to New Hampshire to find this water.

The figure Mr. Tracy has mentioned for limitation of hardness—22 and up to 44 or 50—is comparatively small. The Great Lakes water is 120, or in that neighborhood. So if Mr. Enslow raises the question as to the need for something to prevent that leaching, I think we should look at it from the standpoint of whether it is wanted.

MR. CHASE. We here in New England are used to soft water, and when the hardness of the water is increased from our roughly normal 25 to 50—and certainly when it is increased to 100—we usually get complaints from the housewife and from the textile industries. Of course there are a lot of industries to whom a hardness of 375 does not mean anything, but to our New England textile industry it does mean something.

MR. MAAHS. I think you are entirely right on it, but each individual case should be considered on its merits.

MR. DONOHOE. I should like to ask Mr. Tracy if there is anything in these figures which he has given us today from which anybody could believe that there is anything detrimental to public health in these increases.

MR. TRACY. No, the question of public health was never involved beyond the first set of samples. Never at any time, so far as the Public Health Department is concerned, has there been any question about the effect of cement-asbestos pipe on water from a public-health standpoint. In fact, there has never been any question about the effect of cement-asbestos pipe on the potability of water.

MR. CAMP. I should like to see cement-asbestos pipe developed so that it is really in competition with cast-iron pipe. The way to do it is to get rid of this leaching. I think that very seriously affects the life of cement-asbestos pipe. We are beginning to get some informa-

tion on it. So far I don't know what the life is, but I don't believe it is anything like the life of cast-iron pipe. If they can stop this leaching, then we shall get something.

A MEMBER. Maybe they have already solved this problem to some extent. Didn't you mention something about the new lines that were put in about a year or so ago—something about their not showing the increased pH or the hardness to the degree that the lines do which were put in 10 to 12 years ago?

MR. TRACY. That is correct. The Proctorsville system and the South Burlington east end extension, both of which are a little more than a year old, do not show anywhere near the percentage increase that was indicated by the observations made in 1945 and 1946. Now, I have confined my paper to the observations which I made and would not pretend to give the reasons, so far as the pipe companies are concerned. The South Burlington pipe is Johns-Manville, and the Proctorsville also, I think. And I think it is War Assets pipe, some of it, although I am not sure.

MR. MAAHS. I might state that the factor of the asbestos-cement pipe which seems to cause some difficulty—increase of alkalinity and hardness—is the free lime in our product. In recent years we have attempted to control that by not using just Portland cement alone, but by using an admixture of silica, and we secure that mixture at elevated temperatures in the presence of moisture, so that we get a chemical combination of free lime with the silica to get more insoluble calcium silica, which may account in part for the observations which Mr. Tracy found.

MR. ENSLOW. Finally I get the answer!

MR. MAAHS. I should like to make just one other comment: On the installations of asbestos-cement pipe the observations have been made and it does show some increase. One thing that has to be taken into account is the time factor, which has not been taken into account in some of these observations which have been reported. You take any industrial user, who uses water in large quantities; the time of retention is comparatively small, so that the pick-up will be comparatively small. It is really where you retain the water, where it might be through a matter of days, that you get the pick-up. You will get that with any ordinary concrete product. Any concrete pipe or cement-lined pipe, or any concrete product, will give you a pick-up over a period of time. Thus the time factor has to be taken into account.

IMPROVING WATER QUALITY BY CLEANING RESERVOIRS AND DRAINING SWAMPS

BY MARSHALL S. WELLINGTON*

[*Read November 17, 1949.*]

THE New Haven Water Co. over a period of 25 years in order to improve the quality of water in regard to color, taste and odor, has cleaned the bottom of two reservoirs and drained many swampy areas. The removal of muck from the bottom of these reservoirs and the large projects of draining swamps will be discussed in this paper.

The first reservoir cleaned in the summer of 1941 was the Prospect reservoir. This reservoir has an area of 8.6 acres, with a maximum depth of water of thirteen feet and an average depth of water of eight feet. The depth of the muck removed from the bottom of the reservoir averaged four feet, although in some places it was over five feet. A portion of this muck was the top soil which had not been stripped before the reservoir was filled. The cost of removing this muck from the reservoir was $.80 per cu yd.

This reservoir, which is over 50 years old, is located in a sparsely inhabited country with very few houses and very little pasture land on the watershed. The banks are planted with pine trees for a distance of at least 100 ft from the shore of the reservoir. The brooks, which flow through hard- and soft-wood forests, are very fast and carry a great many leaves. An attempt is made to catch these leaves by building stilling basins of stones across the brooks. The basins did some good but still a large amount of material was carried into the reservoir.

In the early thirties a swampy, earthy taste started to develop in the water. This became progressively worse and was accompanied by growths of micro-organisms, which were destroyed only with great difficulty by the use of copper sulphate. The condition became so bad that this source of the water supply had to be abandoned in 1935.

In 1941 this supply was needed and, as the quality of the water had not improved, desperate means were needed to improve it. It was decided to drain the reservoir and remove the muck from the bottom.

*Sanitary Engineer, New Haven Water Co., 72 Holcomb Street, West Haven, Conn.

The company which had the contract to remove this muck at first attempted to do it by using a road-scraping truck, drawn by a tractor. This method proved unsatisfactory, because the bottom of the reservoir was so uneven that it was nearly impossible to draw the truck. Furthermore, the muck was so wet that half of the load would be lost before reaching the dump pile. After some trials it was found that the use of a bulldozer to push the mud into piles and a shovel to load these piles into trucks and cart them to the waste pile was the easiest way. We were fortunate to have enough low places not more than 1,000 ft from the reservoir into which the muck could be dumped and not find its way again into the reservoir. The removal of this material from the bottom of the reservoir left a clear, clean gravel.

When the reservoir was filled, it had to be treated once with copper sulphate and allowed to age about 60 days, before the water had physical characteristics which would allow it to be used. Since this source of supply was put into service the water has been in excellent condition.

The second reservoir to be cleaned was the Beaver Brook reservoir. This reservoir was giving the same kind of trouble as was found in the Prospect reservoir—high color, bad taste and odor, and microscopic organisms which made the water appear green. All of these could be controlled by activated carbon and copper treatment, or by treatment with chlorine gas, applied directly to the reservoir. The treatment had to be applied every ten days throughout the summer.

This reservoir was old and we had had trouble with it for many years. We first tried to treat with lime and copper sulphate, to precipitate out the algae that were in it and to kill them. This was all right, except that we had to do it every week and it became a nuisance. Next we tried copper sulphate followed by activated carbon. I think probably that was one of the first attempts to add activated carbon directly to a reservoir. This proved satisfactory, except that it was necessary to do it every two weeks to keep the reservoir in good condition. Then we worked out the idea of seeing what we could do by treating with chlorine gas. We fixed up a boat with an outboard motor and a gasoline-driven pump to operate an injector, and we put six cylinders of gas on both sides, connected them to the injector and started the pump, putting the gas in just as fast as we could take it out of the cylinders, the boat

meanwhile running up and down the reservoir. We were able to put in anywhere from 400 to 600 lb of chlorine in a day, with a residual chlorine in the water of the lake of about 1½-2ppm. However, as this treatment did not seem to do any good, we finally had to abandon this treatment. As we had obtained satisfactory results by removing the muck from Lake Prospect, it was decided to apply this method to the Beaver Brook reservoir.

The watershed of Beaver Brook is 1.3 sq mi in area and is sparsely inhabitated. The run-off is rapid, in spite of considerable swampy area. The reservoir is surrounded by pines but most of the watershed area is covered with deciduous trees.

The reservoir which is formed by damming Beaver Brook has an area of 13.1 acres and stores 19 mil gal of water. The maximum depth of the water is eighteen feet with an average depth of eight feet. The ground was not stripped before flooding. The average depth of the muck was three feet, but we found places where the peat was more than twelve feet deep.

Bulldozers, shovels and trucks were used to remove the muck to a gravel bottom, at a cost of $.75 per cu yd. Again we were fortunate enough to have a place to dump the removed material near at hand, and this circumstance helped to reduce the cost.

The peaty area was about 300 ft square and of such an elevation that it was covered by about three feet of water. In order to find a gravel bottom under this area, it was necessary to excavate to a depth of about twelve feet. The removal of the peat area, which was done in the winter, was made easier as the ground was frozen enough to allow a shovel with a clam-shell bucket and trucks to operate on its surface. This entire area of peat was not removed to a depth of twelve feet, as the cost would have been too great. We removed about one-half of it to a depth of twelve feet and figured that, when the reservoir was filled, the remainder of the area would slump. This actually happened and the average depth at this point is now ten feet. When the reservoir was filled, it took about three months and a treatment of copper sulphate to produce satisfactory water. Since the summer of 1944, when the use of the water was started, its physical characteristics have been enirely satisfactory.

Besides cleaning these two reservoirs we have three areas where

a considerable amount of ditching has been done, to remove stagnant water from swamps, so that a highly colored water would not enter the reservoir.

The ditch on the Lake Wintergreen supply, dug in 1922, is 8,500 ft long and drains an area of about three acres. This ditch is about four feet wide on the bottom and ten on the top. A length of 4,000 ft has a grade of 1:600 and the remainder of the ditch has a grade of 1:1,200. The material excavated was very wet and kept sliding back into the ditch. This was stopped by constructing a woven wood fence, which, although it was erected in 1922, still stands along the side of the ditch. This fence was made by driving wooden stakes three feet apart and then weaving saplings between them. This held the mud back in a satisfactory manner.

The bottom of the ditch at the end of the construction was a hard white substance, but on getting wet it softened up and was carried into the reservoir as a white colloidal material. This made it necessary to pave the bottom of the ditch with stone. The grade of 1:1,200 is too flat, in that the movement of the water is too slow to keep the ditch clean. Cat-tails grow abundantly and it requires the attention of two men the entire summer to maintain the ditch in such a condition that the water will run freely through it. The ditch now brings water into the lake with good physical qualities, instead of a highly colored swamp water such as originally entered the lake. As 50% of the water from the watershed area had to traverse this swampy area, it was well worth the effort to construct the ditch.

The quantities of earth removed and the cost figures are not available, as the project was done by our own men at a time when other work was slack.

The next swampy area drained was at Beaver Brook reservoir. At this location practically all the water flowing into the reservoir comes through a swampy area of one acre. The main ditch starts at some springs, which are the main source of supply, and is six feet wide on the bottom, which is three feet below normal ground surface. This ditch is about 4,000 ft long, with a grade of about 1:1,000. The bottom of this ditch is a very good grade of gravel and the flow of water is rapid enough to eliminate most of the growths on the bottom. Twice through the summer the ditch is cleaned, and it takes about ten days and two men to do this work.

At the lower end of the ditch was an area of about 400 sq ft of stagnant water, caused by the backing-up of the water in the reservoir. This condition has recently been corrected by laying 400 ft of 42-inch cast-iron pipe with tight joints on a grade of 1:400 and then filling the entire area with gravel.

All of this ditching and piping has allowed the water entering the reservoir to be very clear and of low color, where in the past it had a high color and very bad taste and odor.

The third swamp to be drained is the Brenski swamp area of the Lake Gaillard watershed. This work, which was done in 1943, drains a swampy area of 280 acres. This area can be divided into two sections, the north section and the south section. The north section has 7,788 ft of reinforced concrete pipe, including the side laterals, 24 to 48 in. in diameter, with 21 manholes. There are 6,350 ft of ditch with a maximum depth of nine feet, with a total excavation of 30,000 cu yd.

In laying this concrete pipe the ditch was excavated, the pipe laid about an inch apart, the section around the opening of the pipe back-filled with crushed stone of about one inch in diameter, and then the entire ditch back-filled with the excavated material and the whole section leveled off with a bulldozer.

The south section has 3,020 ft of concrete pipe, varying in size from 24 in. to 8 in. in diameter, with seven manholes. This pipe was laid in the same manner as the north section.

The cost of construction of this drain can be broken down as follows: Excavation, $.90 per cu yd; concrete pipe, about $2.00 per ft, and the laying of the pipe, about $2.00 per ft.

This area before the draining was practically covered with water and was nearly impassable. After the finish of the construction, the entire area was accessible, and it has been possible to thin out the underbrush and leave a fair stand of timber. Also, the water leaving this swamp and entering the reservoir, before this construction was undertaken, was extremely high in color, probably running as high as 300 ppm. At the present time the highest color noticed has been 60 ppm, the water at most times having a color of less than 20 ppm.

By draining these three swamps and cleaning the bottom of the two reservoirs we have been able to produce water in the reservoirs of a very satisfactory character.

DISCUSSION.

E. SHERMAN CHASE (Boston, Mass.). I wonder if Mr. Wellington tried covering any of the peat with clean gravel?

MARSHALL S. WELLINGTON. No, we did not try that, Mr. Chase. We had the reservoir empty and everything there, and we just decided the best way was to take it all out and not bother with covering it up.

DONALD C. CALDERWOOD (Nashua, N. H.). Do you have any record of the amount of water that was lost through the ground before and after this matter was removed from the bottom? I should think that, if you had the gravel exposed and the water was on top of it, it would allow it to seep through the soil and come out somewhere else.

MR. WELLINGTON. We have no record of it at all. We were fortunate in one of our reservoirs. A main highway went across the reservoir about 100 ft from the main dam and we did not clean that section between the highway and the main dam, so that, if there was any seepage, it would come out into the lower reservoir.

FREDERICK O. A. ALMQUIST (Hartford, Conn.). I would like to ask Mr. Wellington if there were not some investigations made as to the filtration of these supplies?

MR. WELLINGTON. Yes, we made an investigation of the filtration of the Beaver Brook supply and we found that it could be done, but we ran into several coagulation difficulties in doing it and we felt that these difficulties would more than offset the cleaning of the reservoir.

MR. CHASE. May I ask another question? Have you the records of the color before and after, and, if you have them, won't you dig them out and put them into the published paper?

MR. WELLINGTON. The only color record we have is at Lake Gaillard. At the time we ditched the other two reservoirs, the color did not interest the people very much. That was done in 1918, 1919 and 1920, and at that time people were not interested at all in color; they just wanted the supply for the water more than anything else. At that time we would get a maximum color of 300 and most of the time nowadays it is way down to 20.

MR. CHASE. I am thinking of the reservoir out of which you dug the muck.

MR. WELLINGTON. We have some recent colors, but the older times we have no record of at all.

MEMOIR OF JAMES F. SANBORN

The late James F. Sanborn was one of the oldest members of this Association, having joined June 24, 1908. He was born in Sanborn, Colo., the son of Jeremiah and Anna (Batchelder) Sanborn, September 5, 1876. He spent his boyhood in Templeton, Mass., and was educated at Cambridge Latin School and Harvard University, graduating with honors from the Lawrence Scientific School in 1899 with a degree of S.B. in Mining and Metallurgy.

For several years after graduating his employment varied from mining in Montana and the Lake Superior region to work on the construction of the New York subways, where he was in charge of important work on the first subway built under compressed air across the East River.

From 1905 to 1919 he was with the New York Board of Water Supply, first as Associate Engineer and later as Division Engineer on a large section of the Catskill Aqueduct. From that time until his death November 12, 1949, he practiced consulting engineering and made many important contributions to the success of water-supply, sewerage and other sanitary developments. He operated from New York City as his headquarters, one of his early associations being with the firm of Sanborn and Bogert. In the earlier years his work varied from design and construction of complete water-supply and sewerage systems for Kingston and other towns along the Hudson River, Hampton Bays and other districts on Long Island to others equally important in Connecticut and New Jersey.

Going farther afield, his talents as a geologist were of particular value to the Greater Vancouver District in its pressure-tunnel construction for water supply. His activities extended to other countries. As early as 30 years ago he reported on the water supply and sewerage of the city of Santo Domingo. At the invitation of the Cuban government he collaborated with Dr. Charles P. Berkey and the late J. Waldo Smith in an investigation of additional water-supply sources for Havana. Before and during World War II he engineered the design and layout of several of the government's air fields, both in this country and abroad, the latest being in Cuba in 1942.

Along with his consulting work he was also for a time an Associate Professor in the Department of Geology at Columbia University. One of his most notable contributions in the field of engineering geology was made in collaboration with Dr. Charles P. Berkey of Columbia. Recording their experiences on the construction of the Catskill Aqueduct, they presented to the American Society of Civil Engineers a classic paper on the "Engineering Geology of the Catskill Water Supply", which was awarded the J. James R. Croes Medal in 1923.

His services were in demand as an expert court witness, notably in the important water-diversion cases of the New York Board of Water Supply and the Boston Metropolitan District. He is perhaps best known to engineers in Boston for his work as consulting engineer for the former Metropolitan District Water Supply Commission on the construction of its Hultman Pressure Aqueduct and other important features of the new Quabbin Water Supply.

He enjoyed the confidence not only of public officials but of many contractors, and his services were often sought as an abitrator in contract disputes as well as in consultations on heavy construction problems.

One outstanding characteristic was his interest in young engineers and he was never too busy to give them a patient hearing. For years, he gave freely of his time to the Harvard Engineering Society Employment Bureau. He had a most genial personality and was known to everyone—lawyers, sandhogs, engineers, walking bosses—as "'Jim" or "Jimmy".

Besides the N.E.W.W.A. other associations to which he belonged were the American Society of Civil Engineers, the American Water Works Association, the American Institute of Consulting Engineers, the American Society for Testing Materials, the New York Society of Municipal Engineers, the New York and also the New Jersey Sewage Works Association, and the American Public Health Association.

He married Hazel Straight September 19, 1911, and had five children, one son and four daughters. His family ties were particularly close on account of the early death of his wife. Even his children called him "Jim" instead of "Dad". Only recently, June 9, 1948, he married Dorothy Boswell Barbour, the widow of his friend, the late Frank A. Barbour, well-known Past President of this Association.

KARL R. KENNISON

MEMOIR OF GEORGE H. FINNERAN

George H. Finneran, aged 78, died on January 23, 1950, in a hospital at Orlando, Fla., after a brief illness. He had been making his home in Florida in recent years. He had been an employee of the city of Boston, Water Division, for more than 40 years.

Mr. Finneran was first appointed as a Clerk on July 1, 1893, and through sheer application of ability was promoted to Chief Clerk, then General Foreman and finally to Superintendent, a position he held for 25 years prior to his retirement on July 31, 1934. Mr. Finneran was well known to Water Department officials throughout New England, having written much valuable and informative material pertaining to water works.

In collaboration with Edward J. Bachellor, Master Mechanic of the Water Division, he designed the hydrant, known as the "B. & F.", that is used almost exclusively in the Boston Water Department. He was instrumental also in furthering and building a closing device for large gate-valves that saved much labor and valuable time.

A member of the New England Water Works Association since November 14, 1906, he served as President of the Association during the years 1930 and 1931.

He is survived by his widow, Katheryn.

Mr. Finneran's entire active life was devoted unsparingly and unselfishly to the work he loved so well. His passing is deeply regretted by all of us whose good fortune it was to have been associated with this competent, progressive and gentle man.

DANIEL M. SULLIVAN

MEMOIR OF HARRY W. CLARK

Harry W. Clark died at his home in North Andover, Mass., on March 16, 1950, in his 87th year.

Coming as a young man fresh from school in January, 1888, he became a member of the staff of the Lawrence Experiment Station at the beginning of what Gordon M. Fair has called "a decade of sanitary investigation, the like of which has never been seen again." Among

the memberships and the investigations in which Mr. Clark played a part are the Metropolitan water supply and sewerage system of Greater Boston and the Charles River dam and basin.

In 1898, he was given charge of the Experiment Station and the Water Laboratory of the State Board of Health and he continued in these capacities until his retirement as Director of the Division of Water Laboratories of the Massachusetts Department of Public Health in September, 1933. During this period he had an important role in the inception and development of the activated-sludge process and was a pioneer in the treatment of industrial wastes.

After a few years of consulting work following his retirement from state service, he retired to his library for his favorite study of history and biography, although he still retained his keen interest in sanitation and only last summer discussed with the writer problems concerning the water supply of his town.

He was the author of many important papers and received many honors, among which he particularly prized the Dexter Brackett medal, awarded him in 1927. He was a member of many scientific societies. His membership in the New England Water Works Association dated from 1894 and he was elected to honorary membership in 1929.

JOSEPH A. MCCARTHY

LETTER RELATIVE TO DEATH OF AUBREY THOMAS HOBBS

April 7, 1950

MR. NORMAN J. PUGH, PRESIDENT
Institution of Water Engineers
Parliament Mansions
Abbey Orchard Street
London, S.W.1, England

DEAR MR. PUGH:

It was with deep regret that the New England Water Works Association received word of the death of Aubrey Thomas Hobbs on January 12, 1950.

The Association recognizes the great loss which his death means to the water-works profession and particularly to the Institution of Water Engineers, which he served so faithfully as its Secretary for a quarter of a century and as the Editor of the Journal.

The reciprocal relations between the Institution and the New England Water Works Association received his wholehearted coöperation and in his death the Association has lost a valued friend.

Very truly yours,

NEW ENGLAND WATER WORKS ASSOCIATION
(*Signed*) JOSEPH C. KNOX, *Secretary*

PROCEEDINGS

February 1950 Meeting

Hotel Statler, Boston, Mass.

Thursday, February 16, 1950

President Sidney S. Anthony in the Chair.

Secretary Knox announced the election of the following to membership in the Association:

Francis X. Crowley, Preload Corp., Boston, Mass.; William Doubleday, Senior Sanitary Engineering Aid, Massachusetts Department of Public Health, Boston, Mass.; William E. Duffy, Inspector, Water Department, Boston, Mass.; Lester Gaynor, Student, Graduate School of Engineering, Harvard University, Cambridge, Mass.; Frank J. O'Halloran, Senior Chemist, Massachusetts Department of Public Health, Boston, Mass.; John A. Steinberg, Chemist, Massachusetts Department of Public Health, Boston, Mass.; Hyman J. Steinhurst, Junior Sanitary Engineer, Massachusetts Department of Public Health, Boston, Mass.

A talk on "The Current Water-Supply Situation in New York City" was given by Edward J. Clark, Chief Engineer, Bureau of Water Supply, Department of Water Supply, Gas and Electricity, New York, N. Y.

A talk on "Bristol, New Hampshire, and the New Water Supply" was given by Howard E. Bailey, Consulting Sanitary Engineer, Boston, Mass.

A paper on "Ground-Water Supply for New Britain, Connecticut" was read by George W. Wood, Chief Engineer, Board of Water Commissioners, New Britain, Conn.

March 1950 Meeting

Hotel Statler, Boston, Mass.

Thursday, March 16, 1950

President Sidney S. Anthony in the Chair.

Secretary Knox announced the election of the following to membership in the Association:

Associate Member—S. Morgan Smith Co., York, Pa.

Members—Lindsay M. Collins, Consulting Engineer, Holyoke, Mass.; Rolf Eliassen, Professor of Sanitary Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

PRESIDENT ANTHONY. It is my sad duty to announce the death on February 3 of Albert W. Read, Superintendent of the Bangor, Me., Water Department. Mr. Read had been superintendent of this water department since about 1928 and became a member of this Association on August 8, 1928. I suggest we all rise for a moment and stand in silence. [The members stand in silence.]

Upon motion of Richard H. Ellis, duly seconded, it was VOTED

that the specifications for disc-type cold-water meters, as published in the December, 1942, JOURNAL of the Association and previously accepted as tentative on March 18, 1943, together with the specifications published in the September, 1947, JOURNAL for current, compound and fire-service meters, be adopted as standard specifications for the New England Water Works Association.

Upon motion of Leland G. Carlton, duly seconded, it was VOTED

that the nominating committee for this year consist of the last five past presidents, excluding those who are on the Executive Committee at this time, but including Karl R. Kennison, Chairman, Francis H. Kingsbury, Horace L. Clark, Harold W. Griswold and Arthur L. Shaw.

A paper on "How Good Is New England as a Location for Manufacturing?" was read by Arthur H. Bright, Jr., Industrial Economist, Federal Reserve Bank, Boston, Mass.

A paper on "Wickham Hill Storage Reservoirs—a Variation in the Design of Distribution Storage Facilities" was read by William Dorenbaum, Designing Engineer, Water Bureau, Metropolitan District of Hartford County, Hartford, Connecticut.

A paper, illustrated by lantern slides, on "Humor Patented," was read by Charles G. Richardson, Vice-President, Builders-Providence, Inc., Providence, R. I.

PUBLIC UTILITIES UNDER THE AMENDED FEDERAL WAGE-HOUR LAW*

The January 25, 1950, amendments of the Fair Labor Standards Act—the Federal Wage-Hour Law—make no change with respect to application of this 11-year-old law's minimum wage and overtime pay provisions to employees of public utilities furnishing heat, light, power, and water. But the amendments make the law's child-labor provisions more meaningful in this industry by placing a direct prohibition on the employment of young boys and girls.

As before the amendments, public-utilities employees come within the scope of the Wage-Hour Law's application because of their relationship to the production of goods for commerce. This means that the new minimum wage requirement of 75 cents an hour and the overtime pay requirement, which still provides for time and one-half an employee's regular rate of pay for work after 40 hours in a workweek, apply to employees in this industry.

Operators of heat, light, power, and water establishments, therefore, should be concerned about their compliance with the Wage-Hour Law's provisions. Most recent investigation results, for the year ended last June 30, show that the U. S. Department of Labor's Wage and Hour and Public Contracts Divisions found more than $350,000 in back wages due to nearly 2,300 employees in heat, light, power, and water establishments. The back wages were owed because of failure to pay overtime for work after 40 hours in a workweek, and even for failure to pay the minimum wage—then 40 cents an hour.

Before the amendments took effect, employees of public utilities were within the scope of the Wage-Hour Law because their work was "necessary" to the production of goods for interstate commerce by the plants to which they provided heat, light, power, or water. Under the amendments, the word "necessary" was removed from the law, and the phrase "in any closely related process or occupation directly essential to the production" of goods for interstate or foreign com-

*Received April 22, 1950, from Wage and Hour and Public Contracts Divisions, U. S. Department of Labor, Washington 25, D. C.

merce was substituted as a test for determining which employees are within the scope of the law's provisions.

However, in making this change the Congress specifically stated that "employees of public utilities, furnishing gas, electricity or water to firms within the State engaged in manufacturing, producing, or mining goods for commerce, will remain subject to the Act," because such employees "are doing work that is closely related and directly essential to the production of goods for commerce."

By placing a direct prohibition on the employment of young boys and girls employed in interstate or foreign commerce or in the production of goods for such commerce, including those "in any closely related process or occupation directly essential to the production," the amendments make the child-labor provisions generally applicable where the minimum wage and overtime pay provisions apply. Therefore, employers in the public-utilities industry must now give closer attention to the Wage-Hour Law's provisions, under which boys and girls may not be employed under the minimum age of 16 for general employment, and under 18 in specific occupations found by the Secretary of Labor to be hazardous. However, minors 14 and 15 years old may be employed in office work outside of school hours under specific hour limitations.

Under the amendments, as before, the Wage-Hour Law provides specific exemptions for certain so-called "white-collar" workers. These exemptions are subject to revised regulations (Part 541) issued by the Administrator of the Wage and Hour and Public Contracts Divisions, and apply to employees employed in bona fide "Executive," "Administrative," "Professional," "Local Retailing," and "Outside Salesman" capacities.

Since employers must prove the applicability of an exemption of this type, they are advised to consult the Divisions for guidance. Regional offices are maintained by the Divisions in Boston, New York, Philadelphia, Cleveland, Birmingham, Chicago, Kansas City, Dallas, and San Francisco, and inquiries should be directed to the nearest office.

INDEX OF ADVERTISERS

	Page
Atlas Mineral Products Co.	xxvi
Badger Meter Mfg. Co.	Following front cover
Bailey, Howard E.	ii
Builders-Providence, Inc. Division of Builders Iron Foundry	xii
Camp, Thomas R.	ii
Cast Iron Pipe Research Assn.	xxxi
Cement Lined Pipe Co.	iii
Centriline Corporation	Following front cover
Chapman, R. E.	ii
Chemical Fire & Rust Proofing Corp.	xxvi
Eddy Valve Co.	xix
Edson Corp., The	xxi
Eureka Pipe Co., Inc.	xxvi
Fairbanks-Morse Co.	xi
Fay, Spofford & Thorndike	ii
Flexible Sewer Rod Equipment Co.	xxii
Ford Meter Box Co.	Following front cover
Gunite Restorator	ii
Haley & Ward	ii
Hays Mfg. Co.	xvii
Hersey Mfg. Co.	iv
Hilco Supply	xvi
Hughes, Edward F., Co.	iii
Hydraulic Development Corp.	x
Johns-Manville	Following front cover
Keasbey & Mattison Company	xxviii
Kennedy Valve Mfg. Co.	xiii
Knowles, Morris, Inc.	ii
Koppers Company, Inc.	Following front cover
Layne-New York Co., Inc.	iii
Leadite Co.	Back cover
Leggette, R. M.	ii
Lock Joint Pipe Co.	Following front cover
Ludlow Valve Mfg. Co.	Following front cover
Maher, D. L., Co.	iii
Metcalf & Eddy	ii
Morris Machine Works	xviii
Mueller Co.	Following front cover
National Lead Co. of Mass.	xv
National Water Main Cleaning Co.	viii
Neptune Meter Co.	vii
Northrop & Co.	ix
Omega Machine Co. (Division of Builders Iron Foundry)	v
Pierce-Perry Co.	iii
Pipe Founders Sales Corp.	xxii
Pirnie, Malcolm	iii
Pitometer Co.	iii
Pittsburgh Equitable Meter Co.	Following front cover
Joseph G. Pollard Co., Inc.	xv
H. R. Prescott & Sons	xxvi
% Proportioneers, Inc. %	Following front cover
Red Hed Mfg. Co.	xxiv
Rensselaer Valve Co.	xxvii
Reppucci, C. & Sons, Inc.	iii
Ross Valve Mfg. Co.	xxiii
Smith Mfg. Co., The A. P.	Following front cover
Turbine Equipment Co.	xiv
U. S. Pipe and Foundry Co.	xxxiv
Utilities Supply	xxii
Wallace & Tiernan	xx
Warren Foundry and Pipe Corp.	xxi
Welsbach Corporation	xxv
Weston & Sampson	iii
Whitman & Howard	iii
Wood, R. D., Co.	Following front cover
Worthington Pump and Machinery Corp.	vi

(Classified index on page xxix)

ENGINEERS

HOWARD E. BAILEY

Consulting Sanitary Engineer

Water Works — Water Purification
Sewerage — Sewage Treatment
Industrial Wastes Disposal

6 Beacon St., Boston, Mass.

HALEY & WARD

ENGINEERS

Successors to Frank A. Barbour

Water Works and Sewerage Valuations
Supervision of Construction and Operation

TREMONT BUILDING BOSTON, MASS.

MALden 2-3800

Gunite Restoration Co., Inc.

Specializing in Pressure Concrete and Grouting

665 Salem Street, Malden 48, Mass.

R. E. CHAPMAN COMPANY

Oakdale, Massachusetts

GRAVEL DEVELOPED AND GRAVEL PACKED WELLS

All Sizes to 60" Diameter

Best Equipped for Complete Test Drilling and Development of Large Supplies

Tel. WEST BOYLSTON 352 / 47-3

CAMP, DRESSER & McKEE

Consulting Engineers

6 Beacon Street
BOSTON 8, MASS.

Water Works and Water Treatment; Sewerage and Sewage Treatment; Municipal and Industrial Wastes; Investigations and Reports; Design and Supervision; Research and Development; Flood Control.

FAY, SPOFFORD & THORNDIKE

ENGINEERS

Charles M. Spofford — Ralph W. Horne
John Ayer — William L. Hyland
Bion A. Bowman — Frank L. Lincoln
Carroll A. Farwell — Howard J. Williams

Water Supply - Sewerage - Drainage
Structural and Foundation Problems

Investigations Reports Designs Valuations
Engineering Supervision

11 BEACON STREET BOSTON

MORRIS KNOWLES, INC.

Engineers

Water Supply and Purification, Sewerage and Sewage Disposal, Industrial Wastes, Valuations, Laboratory, City Planning.

1312 PARK BUILDING
PITTSBURGH 22, PA.

METCALF & EDDY

ENGINEERS

Water, Sewage, Drainage, Refuse and Industrial Wastes Problems

Airfields — Valuations

Statler Building, Boston 16 — 111 Sutter St., San Francisco 4

R. M. LEGGETTE

Consulting Ground Water Geologist

Water Supply — Salt Water Problems
Dewatering — Investigations
Recharging — Reports

551 Fifth Avenue — New York 17, N. Y.

ENGINEERS

Malcolm Pirnie Engineers
Civil and Sanitary Engineers
Malcolm Pirnie — Ernest W. Whitlock
Richard Hazen — G. G. Werner, Jr.
Investigations, Reports, Plans, Supervision of Construction and Operations, Appraisals and Rates.
25 West 43rd St. New York 18, N. Y.

THE PITOMETER COMPANY
ENGINEERS
Water Waste Surveys
Trunk Main Surveys
Water Distribution Studies
Penstock Gaugings
50 Church Street — New York City

Edward F. Hughes Co.
Water Works Contractor
Gravel, Artesian and Driven Wells
Foundation Borings
427 Riverside Avenue
Medford 55, Massachusetts

Cement Lined Service Pipe
Cement lined pipe has eliminated corrosion and metal contamination for 60 years.
Write for Literature
Cement Lined Pipe Co.
Lynn, Mass.

D. L. MAHER CO.
Water Supply Contractors
Gravel Wall and Driven Wells
Municipal and Industrial Supplies
38B Brattle Street - KIRkland 1438
Cambridge, Mass.

WESTON & SAMPSON
Consulting Engineers
Water Supply and Sewerage
Chemical and Bacteriological
Laboratory
14 BEACON ST. BOSTON, MASS.

WHITMAN & HOWARD
Engineers
Established 1869
Investigations, Designs, Estimates, Reports and Supervision, Valuations, etc., in all Water Works and Sewerage Problems.
89 BROAD ST. BOSTON, MASS.

PIERCE - PERRY CO.
Wholesalers of
Water Works Brass Goods.
Byers Wrought Iron Pipe.
Youngstown Steel Pipe.
Valve and Service Boxes.
236 Congress St., Boston, Mass.
Telephone, Hancock 7817-7818

C. Reppucci & Sons, Inc.
General Contractors
Ground Water Supply
Gravel Packed Wells — Driven Wells
Water Works — Reservoirs
Drainage and Sewerage Works
10 Garden Court St., Boston, Mass.
(Tel. Lafayette 7330)

LAYNE - NEW YORK CO.
Inc.
SUCCESSORS TO
Layne-Bowler New England Corp.
Well Water Supply Contractors
New England Headquarters
15 Ryder Street, Arlington, Mass.

This Hersey Disc Meter, Model HF, will give accurate and efficient service at a low maintenance cost and is built to withstand all climatic conditions.

HERSEY DISC METER, Model HD, is especially built for use in non-freezing climates and is known for its extreme accuracy and low maintenance cost.

HERSEY MANUFACTURING COMPANY

SOUTH BOSTON, MASS.

BRANCH OFFICES: NEW YORK — PORTLAND, ORE. — PHILADELPHIA — ATLANTA — DALLAS
CHICAGO — SAN FRANCISCO — LOS ANGELES

Come to

OMEGA

BELT-TYPE GRAVIMETRIC FEEDERS Highly accurate and adaptable, for rates from 10 to 10,000 lbs. per hr.

LOSS-IN-WEIGHT GRAVIMETRIC FEEDERS Tops in accuracy. Sizes for feeding from ½ to 5,000 lbs. per hr.

UNIVERSAL FEEDERS Simple, dependable feeders for dry materials. Capacities: 1 to 5,000 lbs. per hr.

PRECISION SOLUTION FEEDERS Feed liquids by gravity. No valves, pumps, diaphragms. Available for rates from .08 to 500 g.p.h.

DISC FEEDERS For fine, dry materials. Two models for rates from ½ oz. per hr. to 200 lbs. per hr.

ROTODIP SOLUTION FEEDER Meters and feeds liquids at rates up to 800 g.p.h.

ROTOLOCK FEEDERS Volumetric dry feeders, with capacities to 300 cu. ft. per hr.

LIME SLAKERS Designed for water and sewage plants. Capacities from 175 to 10,000 lbs. per hr.

LABORATORY STIRRERS Six paddle units for laboratory coagulation tests.

Also Dust Collectors and Chemical Elevators for use with the above chemical feeders.

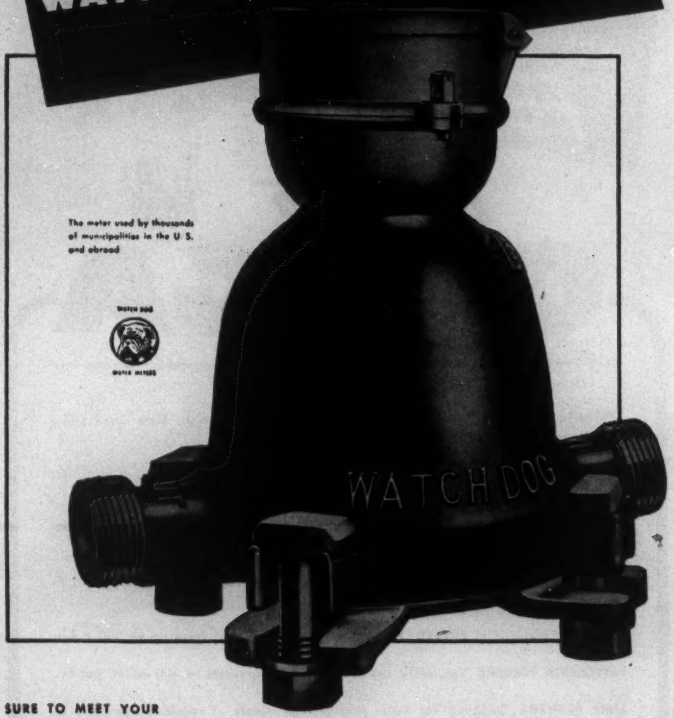
Write for Bulletins and engineering information. Address Omega Machine Company (Division of Builders Iron Foundry), Providence 1, Rhode Island.

THE LAST WORD IN FEEDERS

OMEGA

Worthington-Gamon

WATCH DOG WATER METERS



SURE TO MEET YOUR SPECIFICATIONS FOR ACCURACY, LOW MAINTENANCE, LONG LIFE

Before you invest in water meters, get acquainted with the design and performance advantages which make Worthington-Gamon Watch Dog Water Meters first choice of so many municipalities and private water companies in the United States.

WATCH DOG WATER METERS

"Watch Dog" models . . . made in standard capacities from 30 gpm up: frost-proof and split case in household sizes. Disc type, Turbine type or Compound type. Write for Bulletin.

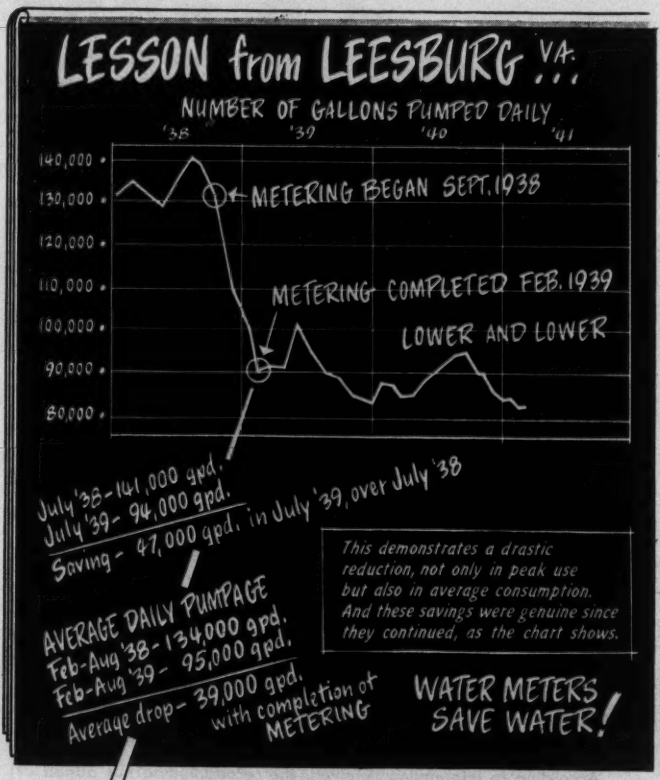
WORTHINGTON-GAMON METER COMPANY

296 South Street, Newark 5, New Jersey

Subsidiary of

WORTHINGTON

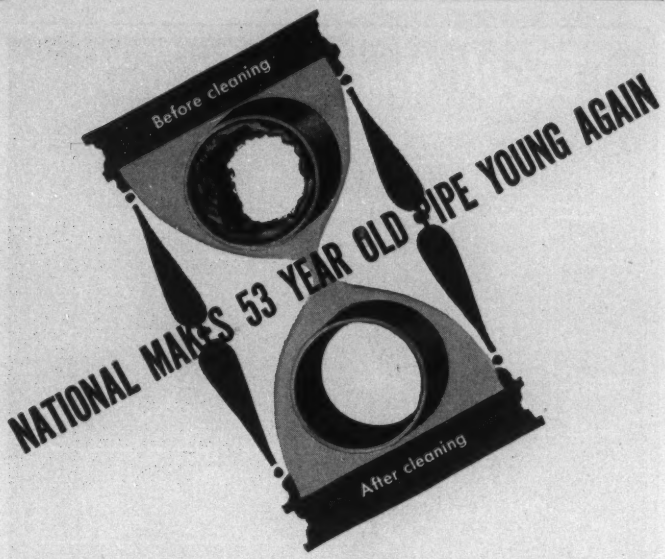
PUMP AND MACHINERY CORPORATION


LESSON from LEESBURG, VA.
NUMBER OF GALLONS PUMPED DAILY
'38
'39
'40
'41
140,000
130,000
120,000
110,000
100,000
90,000
80,000
METERING BEGAN SEPT. 1938
METERING COMPLETED FEB. 1939
LOWER AND LOWER
July '38 - 141,000 gpd.
July '39 - 94,000 gpd.
Saving - 47,000 gpd. in July '39 over July '38
AVERAGE DAILY PUMPAGE
Feb-Aug '38 - 134,000 gpd.
Feb-Aug '39 - 95,000 gpd.
Average drop - 39,000 gpd. with completion of METERING
This demonstrates a drastic reduction, not only in peak use but also in average consumption. And these savings were genuine since they continued, as the chart shows.
WATER METERS SAVE WATER!

METERING ALONE IS NOT ENOUGH . . .

"It must not be taken for granted," writes a prominent Water Works General Superintendent and Chief Engineer, *"that with the installation of meters all troubles come to an end. Meters must be properly maintained . . . Many a water company has become careless in meter maintenance, and as meter efficiency decreased, has looked to increased rates . . . A properly maintained meter department is the most important part of any water system."* Trident Meters, simple, and rugged, with 100% interchangeability of parts, are easy and economical to maintain, at "new meter accuracy" through years of constant service.

NEPTUNE METER COMPANY • 50 West 50th Street • NEW YORK 20, N. Y.
Branch Offices in Chicago, San Francisco, Los Angeles, Portland, Ore., Denver, Dallas, Kansas City, Louisville, Atlanta, Boston.
NEPTUNE METERS, LTD., Long Branch, Ont., Canada



In considering replacement vs. reconditioning of a 53 year old line carrying Water to Chula Vista and National City, Calif., the California Water and Telephone Company decided to recondition the line since replacement in addition to the tremendous cost would have meant disturbing many acres of valuable citrus and vegetable fields.

Reconditioning involved a thorough cleaning by National of over 15,000 feet of 24 inch line, after which the entire line was centrilined.

According to information received, the reconditioning has added at least 20 years more of useful life with a marked increase in the volume of water previously handled.

Our engineers will gladly submit facts and figures on how National has solved similar problems for other utilities. Why not write today?

31

NATIONAL WATER MAIN CLEANING CO., 50 Church St., N.Y. 7, N.Y.

ATLANTA, 333 Candler Building • ATLANTA, 1221 Mortgage Guarantee Building • BOSTON, 115 Peterboro Street • CHICAGO, Room 1336, 122 So. Michigan Avenue • FLANDREAU, S. D., 315 No. Crescent Street • HOUSTON, 2578 Grant Street • KANSAS CITY, 422 BMA Building • LITTLE FALLS, N. J., Box 91 • LOS ANGELES, 448 South Hill Street • OMAHA, 3812 Castellar Street • RICHMOND, 210 East Franklin Street • SALT LAKE CITY, 149-151 Second So. Street • SAN FRANCISCO, 681 Market Street • SIGNAL MOUNTAIN, TENN., 204 Slaxton Street • WACO, P. O. Box 887 • MONTREAL, 2028 Union Ave. • VANCOUVER, B. C., 505 West 1st Ave. • WINNIPEG, 576 Wall Street • HAVANA • MAYAGUEZ,, PUERTO RICO • BOGOTA • CARACAS • MEXICO CITY

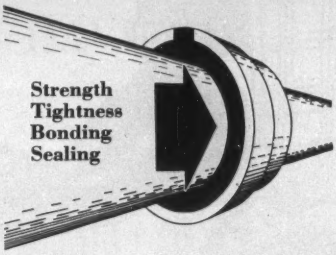
BOND-O

Homogenized

SELF CAULKING COMPOUND

Every bag of BOND-O is a bag of perfect jointing compound.

NORTHROP & CO. INC.
SPRING VALLEY, NEW YORK



THIS SPACE AVAILABLE FOR

YOUR ADVERTISEMENT

(See inside back cover for rates)

Stock Up for Spring Work

4" to 12" C.I. Short Pattern Fittings
4" to 12" Hub End Valves — Cutting-in Valves
All Sizes Tapping Sleeves and Valves
Valve Boxes and Service Boxes
½" to 2" Type K Copper Service Tubing
Brass Fittings and Ford Copperhorns
Saddles and Repair Sleeves for Cast Iron and Cement Asbestos Pipe — Couplings
Bell Joint Clamps — Joint Runners — Tools
Tegul-Mineralead — Hyde-Ro Rings — Jute

Ask for Catalogs and Prices

H. R. PRESCOTT & SONS
110 NORTH PARKWAY, WORCESTER, MASSACHUSETTS
Telephone 3-7535 Day or Night

HYDRO-TITE

WHEN YOU WENT COURTING

A pair of "Bull Dogs" like these and a three-inch starched collar were standard equipment. Probably a sailor straw with a gaily striped band rounded out the ensemble.

Even back in those days HYDRO-TITE was doing its job of making joints in cast iron water mains that were being laid away for keeps.

Styles have changed but HYDRO-TITE is still doing its job. Those joints are right there serving you twenty-four hours a day.

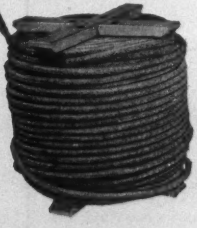
HYDRO-TITE is still made in powder form packed in 100-lb. moisture-proof bags, and now is obtainable also in "LITTLE-PIG" solid form in 50-lb. cartons.

Let HYDRO-TITE go to work for you.

PROTECT YOUR MAINS BY USING

FIBREX

THE BACTERIA FREE JOINT PACKING.



HYDRO-TITE AND FIBREX IN STOCK IN

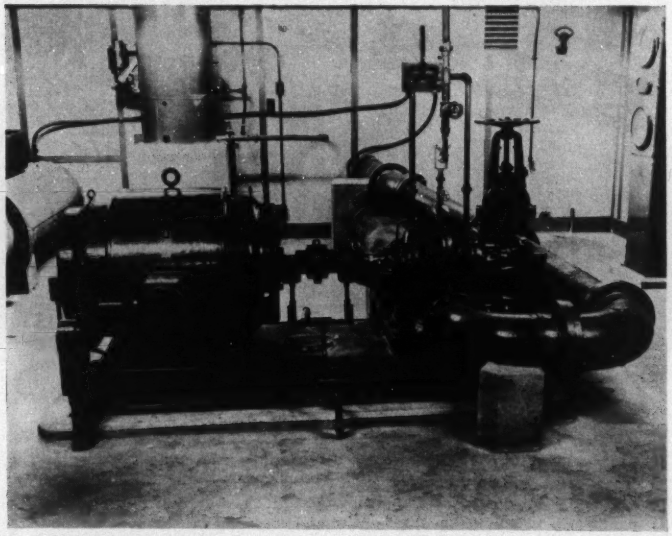
Portland, Oregon	Seattle, Wash.
Kansas City, Mo.	Memphis, Tenn.
Birmingham, Ala.	Orlando, Fla.
Little Falls, N. J.	Boston, Mass.

HYDRAULIC DEVELOPMENT CORP.

***MAIN SALES OFFICE* 50 CHURCH ST., N. Y. C.**

General offices and works W. Medford Sta., Boston, Mass.

WATER FOR HAVERHILL



1750 G.P.M. Fairbanks-Morse Motor Driven Pumping Unit at City of Haverhill, Mass. Kenoza Lake Pumping Station.

The City of Haverhill in order to insure an abundant water supply, recently installed at each of its three pumping stations, Johnson's Pond, Crystal Lake, and Kenoza Lake, a Fairbanks-Morse Fig. 5813 6" 1750 G.P.M. Centrifugal Pump driven by a Fairbanks-Morse 125 H.P. 1800 R.P.M. QZK Motor.

A trained Fairbanks-Morse Engineer is on call to help solve YOUR pumping problems.

Write or telephone to:

FAIRBANKS, MORSE & CO.

178 Atlantic Avenue **Boston 10, Massachusetts**

Telephone: LAfayette 3-3600

FOR FLOW MEASUREMENT AND CONTROL OF LIQUIDS, AIR, DRY MATERIALS

BE WISE . . .

BUILDERS Instruments

STANDARDIZE!

Builders offers you a complete line of FLOW metering and controlling equipment — tested and approved by actual use throughout the waterworks field. For accuracy and dependability, it pays to standardize on BUILDERS — the modern equipment backed by over half a century of continuous research, development, and improvement. For Bulletins and engineering recommendations, address Builders-Providence, Inc. (Division of Builders Iron Foundry), Providence 1, R. I.

PHONE

Providence, GAspee 1-4302 or Boston, Liberty 2-7171

BUILDERS PRODUCTS

THE VENTURI METER • TYPE M SUPER-ACCURATE FLOW METERS

FLO-WATCH MECHANICAL FLOW METERS • PROPELOFLO METERS

CHRONOFLO TELEMETERS • CHRONOFLO ELECTRIC FLOW METERS

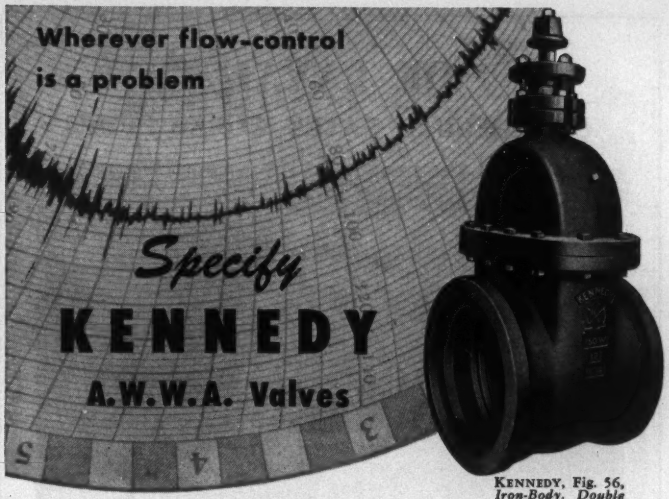
CHRONOFLO CONTROLLERS • CHLORINIZERS-CHLORINE GAS FEEDERS

KENNISON OPEN FLOW NOZZLES • SIGHTFLO INDICATORS

CONVEYOFLO CONTINUOUS WEIGHING SCALES

LIQUID LEVEL GAUGES, RECORDERS AND CONTROLLERS

BUILDERS PROVIDENCE Instruments



KENNEDY, Fig. 56, *Iron-Body, Double Disc Gate Valve.*

Whether it is a hand operated valve on a six inch line supplying a residential area, or an electrically controlled unit on a 48 inch main to a central pumping station, you can obtain the same promise of complete dependability and always-on-the-job performance from every KENNEDY A.W.W.A. valve you install.

Page 15 of the KENNEDY Catalog shows an illustration from the *Scientific American* of October 15, 1892, of a 48 inch KENNEDY Valve that was installed in New York City in that year. Forerunners of the present waterworks valves, many such half-century old KENNEDY valves are still in service . . . ample testimony to the rugged strength and extra service that have always been built into KENNEDY valves.

Conforming to the specifications of the American Water Works Association, KENNEDY A.W.W.A. Valves are especially designed with water works control problems in mind. They are available in all sizes from 3 inches to 60 inches . . . non-rising and outside-screw-and-yoke types . . . with a wide variety of gearing arrangements, controls and accessory equipment available.

Write for complete information

THE KENNEDY VALVE MFG. CO.
1033 EAST WATER ST.
ELMIRA, NEW YORK
VALVES • PIPE FITTINGS • FIRE HYDRANTS

OFFICE-WAREHOUSES IN NEW YORK, CHICAGO, SAN FRANCISCO • SALES REPRESENTATIVES IN PRINCIPAL CITIES

DE LAVAL

CENTRIFUGAL WATER WORKS PUMPS

City of Lynn, Mass., Glen-Lewis Pumping Station

The new De Laval Pump shown above had to be installed in an existing building, and in a limited time—including the removal of an older De Laval Pump that was installed in 1912.

The new unit is rated at 21 M.G.D., and is driven by a 450 RPM, 150 H.P., slip ring motor. The official acceptance test showed that the pumping unit as a whole exceeded the specification minimum efficiency by 3.5 points, and our own guarantee by 2.7 points.

This installation is another in the series made by us under the direction of Morris Knowles Inc., Consulting Engineers for the City of Lynn Water Department.

TURBINE EQUIPMENT COMPANY OF NEW ENGLAND

80 Federal Street **Phone LIberty 2-5993** **Boston 10, Mass.**

New England Representatives for

DE LAVAL STEAM TURBINE COMPANY

TRENTON, NEW JERSEY

Ingot or Wool?

Whether the caulking job calls for ingots for cast lead joints or lead wool for cold caulking, the primary requirement in either case is lead of high purity.

Don't take chances with inferior caulking lead which may have been manufactured from scrap material containing a large percentage of impurities.

When present in a caulked joint, impurities on the surface will corrode and cause weak spots. The stresses due to normal pipe movement concentrate at these areas and failure results.

Our lead, both in ingot and wool form, is made from selected metals and carries the Lead Industries Association Seal of Approval as a guarantee of its quality.

OTHER PRODUCTS—

LEAD PIPE
SOLDER
WHITE LEAD
RED LEAD

NATIONAL LEAD COMPANY

OF MASSACHUSETTS

800 Albany Street **Boston 6, Massachusetts**

M-SCOPE Pipe Finder

LIGHTWEIGHT MODEL

Catalog No. 25F

On Request

JOSEPH G. POLLARD CO., Inc.

Pipe Line Equipment

New Hyde Park **New York**

Tel. SUDBURY 458 P. O. BOX 153

HILCO SUPPLY

delivers

A Complete Line of Waterworks Supplies To All New England

Quality Products — Fast, Courteous and Dependable Service

At the Junction of Routes 20 and 27
SOUTH SUDBURY, MASSACHUSETTS

ANNUAL CONVENTION

of the

NEW ENGLAND WATER WORKS ASSOCIATION

at

POLAND SPRING HOUSE,

Poland Spring, Maine

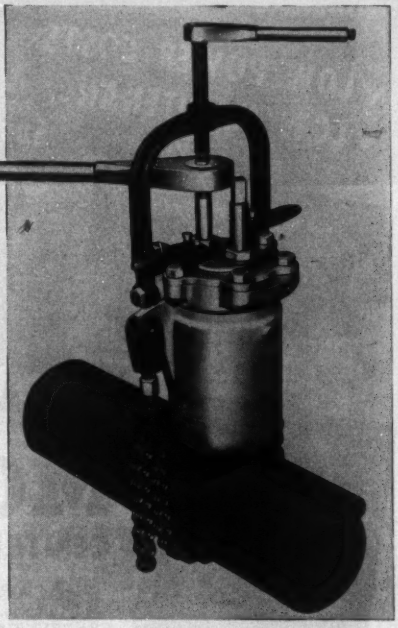
SEPTEMBER 17-20, 1950

DESIGNED FOR THE MAN IN THE DITCH

HAYS

MODEL B TAPPING MACHINE

FOR INSERTING ALL STANDARD MAKES OF CORPORATION STOPS



FASTER . . . Less time required to make a tap • Two ratchet wrenches speed up operations • Head turns freely at all pressures

EASIER HANDLING . . . Shorter height • More rigid attachment to the main • More room in the ditch • Fewer operations—less physical effort required

EFFICIENT . . . Machine fully loaded, ready for operation before placing on the main • No disassembling to insert corporation stop • Flat link chain—positive grip on main

ECONOMICAL . . . Longer life of tools—more taps per tool • Renewable bearings and working parts • Designed to use short pattern taps and screw plugs

See the HAYS MODEL B Tapping Machine demonstrated at the A. W. W. A. Convention in Philadelphia

•

Booths 111, 113, and 115

HAYS

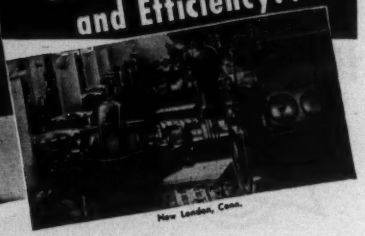
COPPER BRASS LEAD IRON

WATER WORKS PRODUCTS

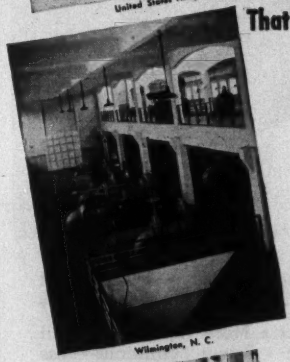
HAYS MANUFACTURING CO., ERIE, PA.

✓LOW POWER COSTS
✓LOW MAINTENANCE & REPAIR COSTS
Sustained Quietness and Efficiency...

United States Army Water Works



New London, Conn.



Wilmington, N. C.

Rocky Mount, N. C.

That's Why So Many Municipal Water Plants *Specify*

MORRIS
CENTRIFUGAL PUMPS

Rugged in construction . . . with design stresses low for smooth, trouble-free operation . . . MORRIS CENTRIFUGAL PUMPS run quietly and uninterruptedly over long periods of continuous operation. Sustained high efficiency—the result of correctly related impeller and casing designs plus Morris' quality construction—keeps power consumption down. Service and repair costs per million gallons are held to a few cents. Daily experience over a period of years confirms the wisdom of selecting MORRIS equipment.

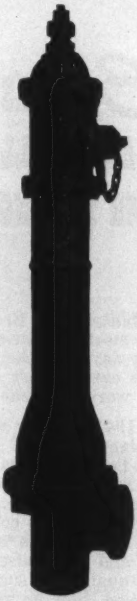
Consult our engineers now regarding your particular needs. There's a MORRIS pump for every job, and more than three-quarters of a century of pump-building "know how" behind every MORRIS pump.

MORRIS MACHINE WORKS, Baldwinsville, N. Y.
Starkweather Engineering Co.
264 Walnut St. Newtonville, Mass.

MORRIS CENTRIFUGAL PUMPS

EDDY

Valves and Hydrants

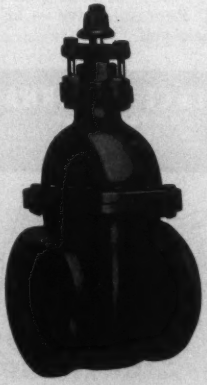


Distinctive Features of the EDDY Valves

ONLY three parts are moved by the Stem—the ball and the two gates. Each gate is hung from one of the trunnions on the ball. A convex surface at the base of each trunnion fits a concave surface on the back of the gate. This allows the gates to adjust themselves properly to their seats. . . . The gates, being free to revolve on the trunnions, do not always seat in the same position. Gates are center bearing and adjustable. They are forced to their seats with equal pressure at all points. There are two hooks on the ball on sizes 4-inch and larger, which loosely engage with the gates.

Distinctive Features of Our New Swivel Top Hydrants

THIS new hydrant has all the advantages of the popular EDDY fire hydrant, plus several additional features. . . . Nozzles are in a short flanged section of the standpipe, which may be unbolted and turned to different positions. . . . Should the standpipe be broken, only the casting below the swivel head need be replaced. . . . To raise the hydrant to conform to a new grading, simply insert a flanged extension piece below the swivelhead. No digging. To add a steamer nozzle at any time, it is only necessary to replace the swivel head with one having a steamer nozzle.



Besides valves and hydrants to meet the most exacting demands of waterworks service, the complete EDDY Line includes: valves for sewage disposal works; valves for steam, gas and oil; check valves, foot valves, plug valves, shear gates, indicator posts, etc. EDDY valves are made in three classes: Iron Body Bronze Mounted, All Bronze, and All Iron Valves.

Eddy Valve Co.

WATERFORD NEW YORK

8 YEARS AND STILL GOING STRONG

The ability of the Break-Point Process to meet the various demands of day by day operation is aptly shown by the case history of a municipal water works in Pennsylvania.

Since 1941, when it was installed at this plant by W&T Engineers, the Break-Point Process has played a major role in producing a pure, sparkling water for the system's many consumers. It has completely eliminated complaints on tastes and odors and has raised the finished water quality to such a high level that tests show *no* gas formers and *no* bacteria on the plates. In addition, a staff report continues, the Break-Point Process was of particular value in keeping the water acceptable to consumers during an emergency plant overload of 120%.

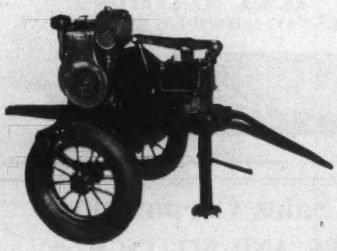
These accomplishments and such additional benefits as longer filter runs and iron and manganese removal are typical of what you receive with the Break-Point Process backed by W&T Equipment.

In the complete line of W&T chlorinating equipment, proved by over 35 years' experience all over the world, there is a chlorinator that will give *your* plant these benefits, too.

For more details write to your nearest W&T Representative — he'll be glad to help you.

EDSON

PUMPS and ACCESSORIES



POWER and HAND

Edson Diaphragms

Depco Centrifugals

Edson Special Hose

Edson Strainers, Foot Valves and Couplings

Pipe Locators - Thawers

THE EDSON CORPORATION

49 D STREET, SOUTH BOSTON, MASSACHUSETTS

Telephone SOuth Boston 8-3041

Warren Foundry & Pipe Corp.

ALSO

Warren Pipe Co. of Mass., Inc.

SALES OFFICES

55 LIBERTY STREET, NEW YORK

75 FEDERAL STREET, BOSTON, MASS.

Manufacturers of

CAST IRON PIPE

Flanged Pipe *Flexible Joint Pipe*

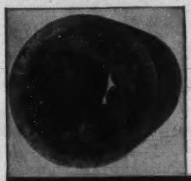
Bell and Spigot Pipe

Special Castings *Short Body B. & S. Specials*

Warren (WF) *Spun Centrifugally Cast Iron Pipe*

WORKS: PHILLIPSBURG, N. J. and EVERETT, MASS.

Large Stock Enables Us to Make Prompt Shipments



Get Full Service From Old Mains

The most practical way to meet today's overload demand is to clean clogged water mains. FLEXIBLE Underground Pipe Cleaning Co., specializes in such jobs— any size—2" to 72".

RAY BAHR

41 GREENWAY, HAMDEN, CONNECTICUT

New England Representative

Pipe Founders Sales Corporation

CAST IRON PIPE AND FITTINGS

FOR

Water, Steam, Gas and Culverts
Special Flanged and Bell and Spigot Castings
Lyncast Iron Chemical Castings

Office: 6 Beacon Street, Boston **Warehouse and Yard: East Cambridge, Mass.**

UTILITIES SUPPLY CORPORATION

Distributors of Water Works Supplies and Materials for Mains and Services

Revere Copper Tubing, Type K

Hays Brass Goods and Erie Service Boxes

Buffalo Gate and Service Boxes

Cast Iron Fittings—AWWA or Short Pattern

Mineralead Jointing Compounds

Construction Tools: Shovels, Cold Cutters, Lanterns, Picks, Sledges.

Jointing Materials: Twisted or Braided Jute, Runners, Pots, Ladles, Hydro Rings, Pig Lead and Lead Wool.

Furnaces: Complete Hauck Line.

Office and Warehouse
425 Riverside Avenue
MEDFORD, MASSACHUSETTS
My 8-9023
My 8-9024

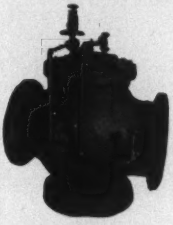
1879—ROSS— 1879

AUTOMATIC VALVES

Controls elevation of water in tanks, basins and reservoirs

ALTITUDE VALVE

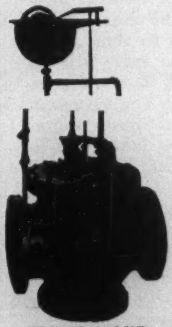
1. Single Acting
2. Double Acting



Maintains desired discharge pressure regardless of change in rate of flow

REDUCING VALVE

Regulates pressures in gravity and pump systems; between reservoirs and zones of different pressures, etc.



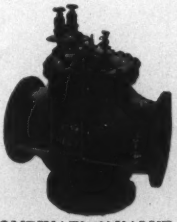
Maintains levels in tank, reservoir or basin

1. As direct acting

2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

FLOAT VALVE

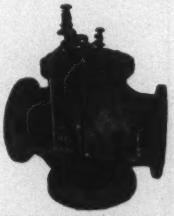
A self contained unit, with controls three or more automatic



COMBINATION VALVE

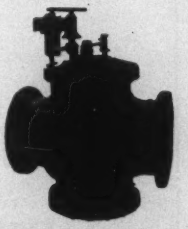
Combination automatic control both directions through the valve.

Maintains safe operating pressures for conduits, distribution and pump discharge



SURGE-RELIEF VALVE

Electric remote control—solenoid or motor can be furnished



REMOTE CONTROL VALVE

Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

ROSS VALVE MFG. CO., INC. Box 592 TROY, N. Y.

RED

HED

RED HED MFG. CO.

Makers of

High Grade Brass Goods for Water Works

368 Congress Street · Boston 10, Mass.

CHASE OUT THOSE DEMONS . . .

WITH *Ozone*

Ozonation comes to the rescue of even the most difficult water purifying problems! There's no need to put up with disagreeable tastes, odor or unsightly color. Why not call on the years of Ozone Research and experience of The Welsbach Corporation, designers and builders of the world's largest Ozone installation for the treatment of municipal water at the Philadelphia Belmont filtration plant. This Ozone installation will eventually treat 70,000,000 gallons daily. OZONE PURIFICATION alone, or in combination with other standard treatments, may be the answer to YOUR taste, odor and color problem.

READ HOW PHILADELPHIA turned to Ozone water treatment: Send today for your copy of the booklet, "Philadelphia Finds the Answer!"

THE WELSBACH CORPORATION

OZONE PROCESSES DIVISION

1500 Walnut Street Philadelphia 2, Pa.

Tegul-Mineralead* AND HYDE-RO RINGS

the best way to join bell and spigot pipe

Tegul-Mineralead is easy and clean to work with, economical, too — needs no skilled labor, caulking or deep bell holes. HYDE-RO RINGS, rubber ring packing, are recommended for use with Tegul-Mineralead. Please write us at 17 Walnut Street, Mertztown, Penna., and request Bulletin No. M10-1 and M10-5.

THE ATLAS MINERAL PRODUCTS COMPANY
MERTZTOWN, PENNA. HOUSTON, TEXAS

*Trade Mark Registered

THE HEFFERNAN PRESS

•

PRINTERS

AND

PUBLISHERS

•

150 FREMONT STREET

WORCESTER, MASSACHUSETTS

Attention Mr. Water Works Superintendent ! !

CEMENT LINED SERVICE PIPE:—

Resists Corrosion

Has proven practical for nearly three-quarters of a century

Immediate delivery can be made to waterworks on both wrought iron and steel, black or galvanized.

"SPECIFY EUREKA PIPE"

EUREKA PIPE COMPANY, Inc.

Manufacturers of CENTRIFUGAL CEMENT LINED PIPE and LEAD AND TIN LINED FITTINGS

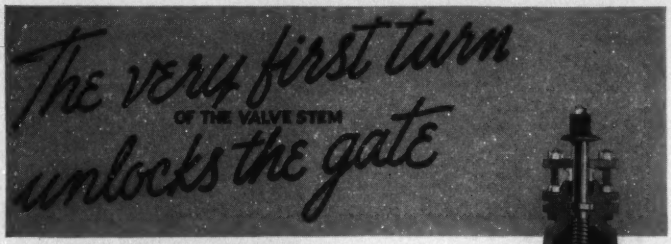
591-593 WASHINGTON ST. TEL. 3-9550 LYNN, MASS.

Chemical Fire and Rust Proofing Corp.

Lining and Coating of Pipe, Couplings, Joints, Tanks, Piling, Structural Steel with Bituminous Enamel or Hydraulic Cement in strict conformity with AWWA Specifications.

Ask for quotations

84½ Berkeley Street, Boston, Mass — LIberty 2-5185



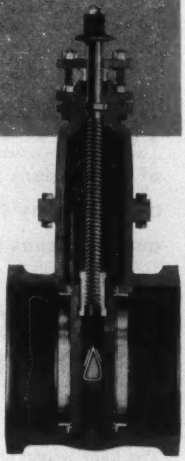
Yes—the FIRST turning movement of the valve stem unlocks the VALVE WEDGING mechanism, and relieves the wedge pressure from both gates of

RENSSELAER
Double-Disc
GATE VALVES

THESE are the famous valves in which the gates are WEDGED closed, squarely and firmly, AFTER they reach the closing point opposite their seats. In opening, the wedging mechanism is positively and mechanically released, loosening BOTH gates. The additional turn of the valve stem simply lifts the LOOSENED gates into full open position.

This simple Rensselaer principle of "wedging" not only makes for ease of opening and closing but also minimizes sliding frictional wear on gate and seat rings.

Experienced Field Representatives are at your call to bring you the benefit of Rensselaer experience in Valves AND Hydrants. Their service puts you under no obligation. Call our nearest office.



TEN POINTS OF SUPERIORITY

1. Easy to Operate—No binding of Stem; Wedges independent of Stem and Stem Nut can't bind.
2. Stems and Stem Nuts both SOLID BRONZE.
3. Wedges, SOLID BRONZE in sizes 10" and larger. Wedges in these sizes have Long and Short Wedging Surfaces. Long side insures greater power in Closing. Short side, maximum ease in Opening.
4. High Tensile Strength, Corrosion Resistant Iron.
5. Stuffing Box Bolts rust-proofed. Nuts BRONZE.
6. Easy to Repack—ample stuffing box depth and diameter.
7. Minimum wear on Rings—Gates Seat, Unseat, in "fully closed" position.
8. Parallel, collapsible Discs—no sticking in closed position or binding of Stem due to tipping.
9. Interchangeable parts—due to precision Casting and Machining.
10. Long Life—Thousands still operating perfectly, some after 50 years.

LEADERSHIP FOR OVER 65 YEARS

RENSSELAER
VALVE COMPANY
Hydrants • Gate Valves • Square Bottom Valves
Check Valves • Tapping Sleeves and Valves • Air Release Valves
TROY, NEW YORK
Division of Neptune Meter Company

Atlanta, Bala-Cynwyd, Pa., Chicago, Dallas, Denver, Haverhill, Mass., Hornell, N. Y. Kansas City, Los Angeles, Memphis, Oklahoma City, Pittsburgh, San Francisco, Seattle

10,000 FEET MORE

of the modern main
that shortens the job
and lengthens the service

IT'S K&M *"Century"* ASBESTOS-CEMENT PIPE

The light weight of this strong K&M Asbestos-Cement Pipe cuts shipping and haulage costs sharply; permits of more economical laying equipment; saves many dollars' worth of time. Even when a radius requires as much as 5° deflection per pipe length, it is easily swung with the "Century" Simplex Flexible Couplings regularly used. This feature, in conjunction with lightness, speeds up any alignment needed before backfill.

Yet all of that merely begins the economies now winning increasing favor for K&M Pipe. This advanced pipe defies electrolysis and is highly resistant to soil corrosion. It doesn't know tuberculation effects; therefore, inside diameter, flow capacity and calculated pumping costs hold constant.

Traffic stresses, earth settlement and chemical attack are all minimized by K&M Asbestos-Cement Pipe—the main that the years don't weaken! As a final economy this pipe is recoverable for re-laying in its original pressure class. You can see why the savings made and the service assured always do credit to those responsible for K&M "Century" Pipe installations. Write us for full data.

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

Nature made Asbestos . . .
Keasbey & Mattison has made it serve mankind since 1873

K&M Asbestos ®

CLASSIFIED DIRECTORY OF ADVERTISEMENTS

AIR COMPRESSORS.
Edson Corp., The ... xxi

ASBESTOS CEMENT PIPE.
Johns-Manville Corp. ... Following front cover
Keasbey & Mattison Company ... xxviii

BRASS GOODS.
Eureka Cement Lined Pipe Co. ... xxvi
Hays Mfg. Co. ... xvii
Hilco Supply ... xvi
Mueller Co. ... Following front cover
Pierce-Perry Co. ... iii
Red Hed Mfg. Co. ... xxiv
Smith Mfg. Co., The A. P. ... Following front cover

CALKING MACHINERY AND TOOLS.
Hydraulic Development Corp. ... x
Mueller Co. ... Following front cover
Northrop & Co. ... ix

CAST IRON PIPE. (See Pipe, Cast Iron.)

CEMENT LINED PIPE. (See Pipe, Cement Lined.)

CHEMICAL FEED APPARATUS.
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) ... xii
Omega Machine Co. ... v
% Proportioneers, Inc. % ... Following front cover
Wallace & Tiernan Co., Inc. ... xx

CHLORINATORS.
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) ... xii
% Proportioneers, Inc. % ... Following front cover
Wallace & Tiernan Co., Inc. ... xx

CLEANING WATER MAINS.
Flexible Underground Pipe Cleaning Co. ... xxii
National Water Main Cleaning Co. ... viii

COCKS, CURBS AND CORPORATIONS.
Eureka Cement Lined Pipe Co. ... xxvi
Hays Mfg. Co. ... xvii
Mueller Co. ... Following front cover
Pierce-Perry Co. ... iii
Smith Mfg. Co., The A. P. ... Following front cover

CONCRETE PIPE. (See Pipe, Concrete.)

CONSTRUCTION AIR TOOLS.
Edson Corp., The ... xxi

CONTRACTORS' EQUIPMENT.
Hydraulic Development Corp. ... x
Northrop & Co. ... ix

CONTRACTORS.
Layne-New York Co. ... iii
Maher, D. L. Co. ... iii
Reppucci, C. & Sons ... iii

COUPLINGS, FLEXIBLE PIPE.
Johns-Manville Corp. ... Following front cover

CURB BOXES.
Eureka Cement Lined Pipe Co. ... xxvi
Hays Mfg. Co. ... xvii
Hilco Supply ... xvi
Mueller Co. ... Following front cover
Pierce-Perry Co. ... iii
H. R. Prescott & Sons ... xxvi

DIAPHRAGMS, PUMPS.
Edson Corp., The ... xxi
% Proportioneers, Inc. % ... Following front cover

ENGINEERS.
Bailey, Howard E. ... ii
Camp, Dresser and McKee ... ii
Fay, Spofford and Thorndike ... ii
Haley and Ward ... ii
Knowles, Morris, Inc. ... ii
Metcalf and Eddy ... ii
Pirnie Engineers, Malcolm ... iii
Weston and Sampson ... iii
Whitman and Howard ... iii

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

ENGINES. (See Pumps and Pumping Engines.)

EQUIPMENT. (See Contractors' Equipment.)

FEED WATER FILTERS.
% Proportioneers, Inc. % ..... Following front cover
Ross Valve Mfg. Co., Inc. xxiii

FILTRATION PLANT EQUIPMENT.
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xii
% Proportioneers, Inc. % ..... Following front cover

FLAP VALVES.
Eddy Valve Co xix

FLEXIBLE JOINTS.
U. S. Pipe and Foundry Co. xxxiv

FURNACES.
Hilco Supply xvi
Hydraulic Development Corp. x
Leadite Co. ..... Back cover
Mueller Co. ..... Following front cover
Northrop & Co. ix
H. R. Prescott & Sons xxvi

GATE VALVES. (See Valves.)

HOSE, SUCTION AND CONDUCTION.
Edson Corp., The xxi
H. R. Prescott & Sons xxvi

HYDRANTS, FIRE.
Eddy Valve Co. xix
Hilco Supply xvi
Kennedy Valve Mfg. Co. xiii
Mueller Co. ..... Following front cover
H. R. Prescott & Sons xxvi
Rensselaer Valve Co. xxvii
Smith Mfg. Co., The A. P. ..... Following front cover
Wood, R. D., Co. ..... Following front cover

HYDRANTS, PUMPS.
Edson Corp., The xxi
Hilco Supply xvi
H. R. Prescott & Sons xxvi

LEAD.
National Lead Co. of Mass. xv

LEAD PIPE. (See Pipe, Lead.)

LEAD WOOL.
National Lead Co. of Mass. xv

LEAK FINDERS.
Edson Corp., The xxi

METERS, OIL AND WATER.
Badger Meter Mfg. Co. ..... Following front cover
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xii
Hersey Mfg. Co. iv
Neptune Meter Co. vii
Pipe Founders Sales Corp. xxii
Pittsburgh Equitable Meter Divn. ..... Following front cover
Worthington-Gamon Meter Co. vi

METER COUPLINGS.
Badger Meter Mgf. Co. ..... Following front cover
Ford Meter Co. xvi
Hays Mfg. Co. xvii
Hersey Mfg. Co. iv
Mueller Co. ..... Following front cover
Neptune Meter Co. vii
Red Hed Mfg. Co. xxiv
Smith Mfg. Co., The A. P. ..... Following front cover
Worthington-Gamon Meter Co. vi

METERS (Venturi Type.)
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xii

METER BOXES.
Ford Meter Co. xvi
Mueller Co. ..... Following front cover

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

METER TESTERS.
Badger Meter Mfg. Co. ..... Following front cover
Ford Meter Co. ..... Following front cover
Mueller Co. ..... Following front cover
Neptune Meter Co. vii

OIL ENGINES.
Edson Corp., The xxi
Fairbanks, Morse Co. xi

OZINATION EQUIPMENT.
Welsbach Corp. xxv

PIPE, ASBESTOS CEMENT.
Johns-Manville Corp. ..... Following front cover

PIPE, BRASS.
Hilco Supply xvi
Pierce-Perry Co. iii
H. R. Prescott & Sons xxvi

PIPE, CAST IRON (and Fittings.)
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xii
Cast Iron Pipe Research Association xxxiii
Hilco Supply xvi
Pipe Founders Sales Corp. xxii
H. R. Prescott & Sons xxvi
U. S. Cast Iron Pipe and Foundry Co. xxxiv
Warren Foundry and Pipe Co. xxi
Wood, R. D. Co. ..... Following front cover

PIPE, CEMENT LINED.
Cast Iron Pipe Research Association xxxiii
Cement Lined Pipe Co. iii
Eureka Cement Lined Pipe Co. xxvi
Pipe Founders Sales Corp. xxii
U. S. Pipe and Foundry Co. xxxiv

PIPE, COATING AND LININGS.
Barrett Division ..... Following front cover
Centriline Corp. ..... Following front cover
Koppers Company, Inc. ..... Following front cover

PIPE, CONCRETE.
Lock Joint Pipe Co. ..... Facing front cover

PIPE CUTTING MACHINES.
Smith Mfg. Co., The A. P. ..... Following front cover

PIPE JOINTING MATERIAL.
Atlas Mineral Products Co. xxvi
Hilco Supply xvi
Hydraulic Development Corp. x
Leadite Co., The ..... Back cover
National Lead Co. of Mass. xv
Northrop & Co. ix

PIPE, LEAD.
National Lead Co. of Mass. xv
Pierce-Perry Co. iii
Red Hed Mfg. Co. xxiv

PIPE LINING.
Centriline Corp. ..... Following front cover

PIPE, PRESTRESSED CONCRETE.
Lock Joint Pipe Co. ..... Facing front cover

PIPE, WROUGHT IRON AND STEEL.
Pierce-Perry Co. iii

PLUG VALVES.
Eddy Valve Co xix
Hays Mfg. Co. xvii
Mueller Co. ..... Following front cover
Pittsburgh Equitable Meter Divn. ..... Following front cover

PITOMETERS.
Pitometer Co., Engrs. iii

PORTABLE AIR COMPRESSORS. (See Air Compressors.)

PRESSURE REGULATORS.
Hilco Supply xvi
Mueller Co. ..... Following front cover
Pittsburgh Equitable Meter Divn. ..... Following front cover
H. R. Prescott & Sons xxvi
Ross Valve Mfg. Co., Inc. xxiii

PROVERS, WATER.
Badger Meter Mfg. Co. ..... Following front cover

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

PUMPS AND PUMPING MACHINES.
- Edson Corp., The ... xxi
- Fairbanks, Morse and Co. ... xi
- Layne-New York Co., Inc. ... iii
- Hilco Supply ... xvi
- Maher Co., D. L. ... iii
- Morris Machine Works ... xviii
- H. R. Prescott & Sons ... xxvi
- Ross Valve Mfg. Co., Inc. ... xxiii
- Turbine Equipment Co. ... xiv

RATE CONTROLLERS AND GAUGES.
- Badger Meter Mfg. Co. ... Following front cover
- Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) ... xii

SHEAR GATES.
- Eddy Valve Co ... xix
- Mueller Co. ... Following front cover

SLEEVES AND VALVE TAPPINGS.
- Eddy Valve Co ... xix
- Hilco Supply ... xvi
- Mueller Co. ... Following front cover
- H. R. Prescott & Sons ... xxvi
- Rensselaer Valve Co. ... xxvii
- Smith Mfg. Co., The A. P. ... Following front cover

SUPPLIES AND TOOLS.
- Hilco Supply ... xvi
- Hydraulic Development Corp. ... x
- Leadite Co., The ... Back cover
- Mueller Co. ... Following front cover
- Northrop & Co. ... ix
- Pierce-Perry Co. ... iii
- H. R. Prescott & Sons ... xxvi

TAPPING MACHINES.
- Hays Mfg. Co. ... xvii
- Mueller Co. ... Following front cover
- Red Hed Mfg. Co. ... xxiv
- Smith Mfg. Co., The A. P. ... Following front cover

TAPPING SLEEVES. (See Sleeves and Valves, Tapping.)

VALVE BOXES.
- Eddy Valve Co ... xix
- Hilco Supply ... xvi
- Kennedy Valve Mfg. Co. ... xiii
- Mueller Co. ... Following front cover
- Pierce-Perry Co. ... iii
- Pipe Founders Sales Corp. ... xxii
- H. R. Prescott & Sons ... xxvi
- Smith Mfg. Co., The A. P. ... Following front cover
- Wood, R. D. Co. ... Following front cover

VALVE INSERTING MACHINES.
- Mueller Co. ... Following front cover
- Smith Mfg. Co., The A. P. ... Following front cover

VALVES, CHLORINE.
- Wallace and Tiernan Co., Inc. ... xx

VALVES, GATE.
- Eddy Valve Co ... xix
- Hilco Supply ... xvi
- Kennedy Valve Mfg. Co. ... xiii
- Mueller Co. ... Following front cover
- Pierce-Perry Co. ... iii
- H. R. Prescott & Sons ... xxvi
- Rensselaer Valve Co. ... xxvii
- Smith Mfg. Co., The A. P. ... Following front cover
- Wood, R. D. Co. ... Following front cover

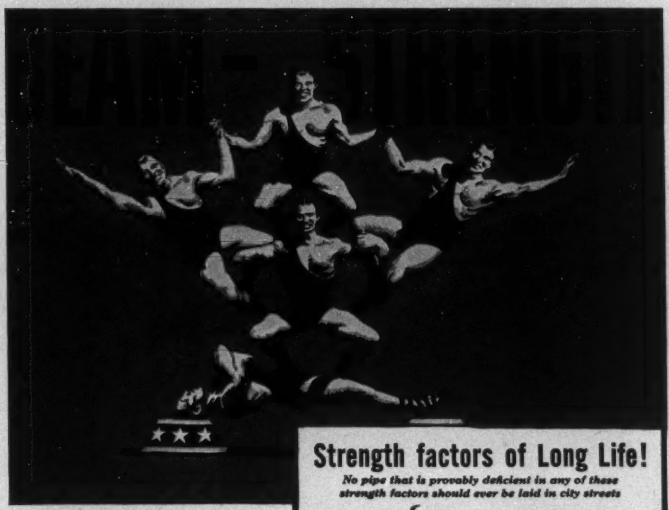
VALVES, REGULATING.
- Mueller Co. ... Following front cover
- Ross Valve Mfg. Co., Inc. ... xiv

WATER WASTE DETECTION.
- Pitometer Co., The ... iii

WELL CONNECTIONS.
- Red Hed Mfg. Co. ... xxiv

WELLS, GRAVEL, FILTER AND DRIVEN.
- Edward F. Hughes Company ... iii
- Maher Co., The D. L. ... iii

WROUGHT IRON PIPE. (See Pipe, Wrought Iron and Steel.)



Without beam strength—or, for that matter—without all of the strength factors listed opposite—no pipe laid 100 years ago in *city streets* would be in service today. But, in spite of the evolution of traffic from horse-drawn vehicles to heavy trucks and buses—and today's vast complexity of subway and underground utility services—cast iron gas and water mains, laid over a century ago, are serving in the streets of more than 30 cities in the United States and Canada. Such service records prove that cast iron pipe combines all the strength factors of long life with ample margins of safety. No pipe that is provably deficient in any of these strength factors should ever be laid in city streets. Cast Iron Pipe Research Association, Thos. F. Wolfe, Engineer, 122 So. Michigan Ave., Chicago 3.

Strength factors of Long Life!

No pipe that is provably deficient in any of these strength factors should ever be laid in city streets

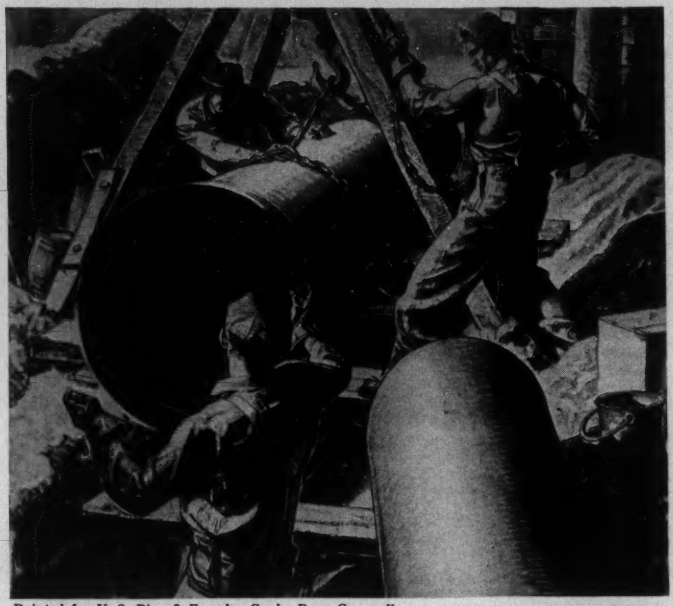
BEAM STRENGTH — When cast iron pipe is subjected to beam stress caused by soil settlement, or disturbance of soil by other utilities, or resting on an obstruction, tests prove that standard 6-inch cast iron pipe in 10-foot span sustains a load of 15,000 lbs.

CRUSHING STRENGTH — The ability of cast iron pipe to withstand external loads imposed by heavy fill and unusual traffic loads is proved by the Ring Compression Test. Standard 6-inch cast iron pipe withstands a crushing weight of more than 14,000 lbs. per foot.

SHOCK STRENGTH — The toughness of cast iron pipe which enables it to withstand impact and traffic shocks, as well as the hazards in handling, is demonstrated by the Impact Test. While under hydrostatic pressure and the heavy blows from a 50 pound hammer, standard 6-inch cast iron pipe does not crack until the hammer is dropped 8 times on the same spot from progressively increased heights of 6 inches.

BURSTING STRENGTH — In full length bursting tests standard 6-inch cast iron pipe withstands more than 2500 lbs. per square inch internal hydrostatic pressure, which proves ample ability to resist water-hammer or unusual working pressures.

CAST IRON PIPE SERVES FOR CENTURIES



Painted for U. S. Pipe & Foundry Co. by Dean Cornwell

U.S. cast iron PIPE

FOR WATER, GAS, SEWERAGE AND INDUSTRIAL SERVICE

You have heard it said that "cast iron pipe is cast iron pipe"—a pipe that gives dependable, long-lived, low-cost service — no matter who makes it. And that is basically a true statement. Why then do we have customers who have regularly purchased from us for over 50 years? One reason is that we have pioneered developments that have resulted in process and product improvements over the years, just as today, through research and development, we strive still further to improve our product. Another reason is that we have been able to give our customers the type of service needed to meet their particular requirements. United States Pipe and Foundry Company, General Offices: Burlington, New Jersey. Plants and Sales Offices throughout U.S.A.

The Journal of the New England Water Works Association

is a quarterly publication, containing the papers read at the meetings, together with reports of the discussions. Many of the contributions are from writers of the highest standing in their profession. It affords a convenient medium for the interchange of information and experience between the members, who are so widely separated as to find frequent meetings an impossibility. Its success has more than met the expectation of its projectors; there is a large and increasing demand for its issues, and every addition to its subscription list is a material aid in extending its field of usefulness.

All members of the Association receive the JOURNAL for three dollars per annum which sum is included in their annual dues; to all others the subscription is four dollars per annum.

TO ADVERTISERS

THE attention of parties dealing in goods used by Water Department is called to the JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION as an advertising medium.

Its subscribers include the principal WATER WORKS ENGINEERS AND CONTRACTORS in the United States. The paid circulation is 1,100 COPIES.

Being filled with original matter of the greatest interest to Water Works officials it is PRESERVED and constantly REFERRED TO BY THEM, and advertisers are thus more certain to REACH BUYERS than by any other means.

The JOURNAL is not published as a means of revenue, advertising being inserted solely to help meet the large expense of publication.

ADVERTISING RATES

	One Issue	Four Issues
One Page	$ 45.00	$120.00
Half Page	30.00	75.00
Quarter Page	18.00	45.00
Eighth Page	11.00	27.00
One Page, 2 Colors	68.00	272.00
Back Cover	100.00	250.00
Cards, 1/12 Page	8.00	20.00

Size of page, 4½ x 7½ ins.

A sample copy will be sent on application.

For further information, address the Advertising Agent,

MISS ALICE R. MELROSE,
73 TREMONT STREET,
BOSTON 8, MASSACHUSETTS

LEADITE

COSTS ARE REDUCED WHEN *LEADITE* IS USED

Of course, the greatest advantage in using LEADITE, is, that it makes a good, tight joint,—and thus reduces leakage to a minimum,—but LEADITE also offers the following advantages, which are worthy of serious consideration: Saves caulking expenses—Reduces cost of digging large bell-holes—Saves in cost of material—Reduces time required for pumping "wet trenches"—Saves time in preparation—Saves time in handling on the job—Saves in freight and hauling charges.

Another point, LEADITE saves "interest charges" by speeding up the completion of the water line.

The true value of LEADITE is best indicated by the fact that it has been used on THOUSANDS OF MILES of Water Mains,—all over this Country, as well as in many Overseas Countries.

The Pioneer self-caulking material for c. i. pipe,
Tested and used for over 40 years,
Saves at least 75%.

THE LEADITE COMPANY

Girard Trust Company Building — Philadelphia, Penna.